TRAFFIC QUARTERLY

AN INDEPENDENT JOURNAL FOR BETTER TRAFFIC

JANUARY 1952

Our First Lustrum
New Jersey's Turnpike
Moving Traffic in Time of Disaster
Improving Manhattan's East Side Traffic
Aesthetic Factors in Parking Lot Design
Urban Transit and Traffic Engineering
A Study of Department Store Parking
Street and Traffic Management
Mid-Manhattan Bus Terminal
Financial Responsibility Law
School-Crossing Hazards
State Highway Systems
Honolulu's Arterial
The 'Yield' Sign

THE ENO FOUNDATION FOR HIGHWAY TRAFFIC CONTROL

EDITORIAL STAFF

Editor-in-Chief	COL. ROBERT C. F. GOETZ, *U. S. A. Retired*
Executive Editor	ROSCOE ELLARD, Director of Instruction, *Graduate Journalism Faculty, Columbia University*
Associate Editors	CHARLES M. UPHAM, *Highway Engineering* WILBUR S. SMITH, *Traffic Engineering* EDWARD G. MOGREN, *Resident Traffic Engineer*
Editorial Assistants	MARY S. BRIODY CHARLOTTE K. MUNGER

Permission to reprint articles from this magazine may be obtained without charge on request to the publishers, Eno Foundation, Saugatuck, Connecticut. Publication of this magazine is provided by income from an endowment by the late William P. Eno.

VOLUME VI, NUMBER 1 JANUARY, 1952

PRINTED BY COLUMBIA UNIVERSITY PRESS, NEW YORK, N. Y.

THE ENO FOUNDATION BUILDING · SAUGATUCK, CONNECTICUT

Traffic Quarterly

TABLE OF CONTENTS, JANUARY 1952

Editorial 3

COLONEL ROBERT C. F. GOETZ

Moving Traffic in Time of Disaster 5

CHARLES G. GONTER

Planning the New Jersey Turnpike 11

CHARLES M. NOBLE

One-way Avenues, Re-timed Signals Improve Manhattan Traffic 16

T. T. WILEY

Layout and Design of Parking Lots: Aesthetic Considerations 27

HAROLD M. LEWIS AND C. EARL MORROW

Street and Traffic Management: A New Approach 40

MAYOR ALBERT E. COBO

The 'Yield-Right-of-Way' Sign 51

PAUL W. RICE

Sizes of State Highway Systems 59

ROY E. JORGENSEN

The Mid-Manhattan Bus Terminal of New York's Port Authority 68

AUSTIN J. TOBIN

Honolulu's Mauka Arterial 76

ROBERT M. BELT

Transit Traffic Engineering 87

BURTON H. SEXTON

A Study of a School Crossing Hazard 102

ROBERT D. DIER

The Department Store and Parking 116

CHARLES O. PRATT

Effect of Financial Responsibility Law on Accident Reporting 128

ALFRED M. KAHL AND A. R. LAUER

Copyright, 1952, by the Eno Foundation for Highway Traffic Control, Inc. Reproduction of Traffic Quarterly articles in whole or part without permission is strictly prohibited. Published quarterly by the Eno Foundation at Saugatuck, Conn., issue for January, 1952. Printed in U.S.A.

Our First Lustrum

THIS is the Fifth Anniversary of the TRAFFIC QUARTERLY. Five years ago it appeared unobtrusively in the field of traffic literature. Every effort has been made to present the highest authorities on all traffic matters and at the same time endeavor to satisfy a widely diversified professional and public interest.

It has constantly kept in mind the importance of creating a volume of reference and information for gratis distribution to those who, if only remotely, may put it to profitable use.

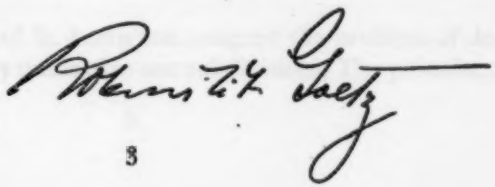
This policy has been diligently pursued with the conviction that full cognizance of our traffic problem prompts one to feel that unless we soon take heed, its far-reaching effects ultimately will approach the importance of other epochs in our national history and growth. It is a national problem that has received only a modicum of the attention it deserves.

Our lack of restraint toward some of its worst tendencies and our passive attitude and cavil toward some of the best means for improving it serve only to aggravate what is rapidly reaching the point of public intolerance.

Some well-meaning officials are impeded at every turn by misguided interests or an uninformed public, that through ignorance cannot, or through contempt will not drive in accordance with the trust implicit in the licenses they hold.

The success of a search for correct knowledge and reliable advanced ideas rests largely with our contributors who have plainly evinced their sympathetic support. Their will to help and their attitude in doing so has been one of our most pleasant experiences.

The interest of public officials in recognizing their needs, and their zeal in seeking information to meet them has been gratifying. It has been some indication of success in furtherance of the purpose of the Eno Foundation: the improvement of traffic. Therein alone lies our reward.



Moving Traffic in Time of Disaster

CHARLES G. GONTER

Mr. Gonter, an electrical engineer, was traffic engineer in St. Louis from 1930 to 1938. He has been Traffic Commissioner since 1949 when the position was created. He is a registered professional engineer in Missouri and Pennsylvania, and a member of the Missouri Society of Professional Engineers.

TRAFFIC engineers' approach to the planning of highway combinations to move emergency traffic in a major disaster should emphasize the uncertainty of where suddenly created devastation may occur.

No single traffic plan can meet every situation. Yet these situations must be foreseen: there should be alternate plans with provision for reasonable modification.

Emergency traffic plans should be based on an existing street system, taking into consideration that system's physical characteristics and its relationship to through-traffic routes and to air, rail and water connection.

The number and mileage of routes serving any devastated area should provide reasonably free movement for the anticipated volume of emergency traffic. Direct, all around, access and egress to the devastated area must be provided.

The plans must avoid conflicts of emergency vehicles by providing independent escape-ways for refugee movements out of any devastated area.

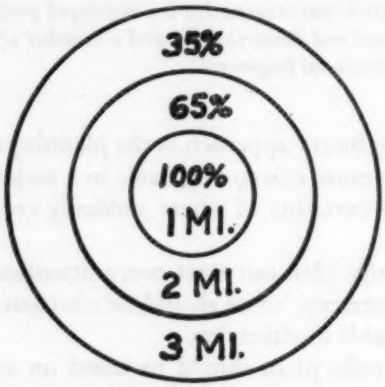
The extent of the emergency highway system is limited by the means likely to be available in an emergency, including manpower for clearance, maintenance and traffic control. Above all, emergency traffic plans must be readily understood and simple in operation.

The St. Louis Emergency Plan

The Traffic Division of St. Louis was assigned the problem of developing an emergency traffic plan and subdivisions. The procedure

in the development of the emergency traffic plan is herein emphasized rather than its operation in an emergency.

To construct suitable plans upon the framework of the foregoing considerations in damage caused by an atomic bomb, it was necessary to ascertain official estimates of the extent of damage by per-



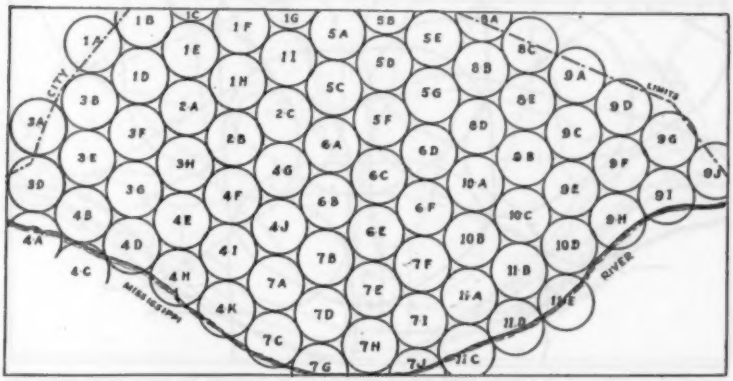
Scaled Bomb Target

centages related to various circular areas. These estimates indicate that within a circular area one mile in diameter, directly beneath a bomb explosion at 2,000 foot elevation, there would result approximately 100 per cent destruction; that within a ring one-half mile wide around the first area there would result approximately 65 per cent destruction, and that within a succeeding one-half mile wide ring there would result approximately 35 per cent destruction. Beyond this latter ring the resulting destruction is indefinite.

Then upon an overlay map of the City of St. Louis, scale 800 feet to one inch, were drawn eighty-two one-mile diameter circles with circumferences tangent to represent as nearly as practicable, the maximum number of such areas that might suffer 100 per cent destruction.

Streets of the city that form a part of state and federal highways were drawn upon an overlay map to serve as a network of emergency traffic aidways. The total length of the network streets is seventy-two miles, as compared with a total of 1,350 miles of streets in the city.

A transparent scaled bomb-target was made to represent the three percentage circular areas of destruction. First, the target was laid with its center coincident with the center of one of the one-mile diameter circles to indicate the extremity of the area that would suffer at least 35 per cent destruction. The purpose of this operation was to discover the relationship between the extremity of that area



This drawing shows the One-Mile Diameter Circles which were drawn upon an overlay map of the city to indicate the maximum number of circular areas any one of which might suffer 100% destruction in the event of an atomic bomb explosion. Each circle is lettered and numbered to make it identifiable for communication purposes.

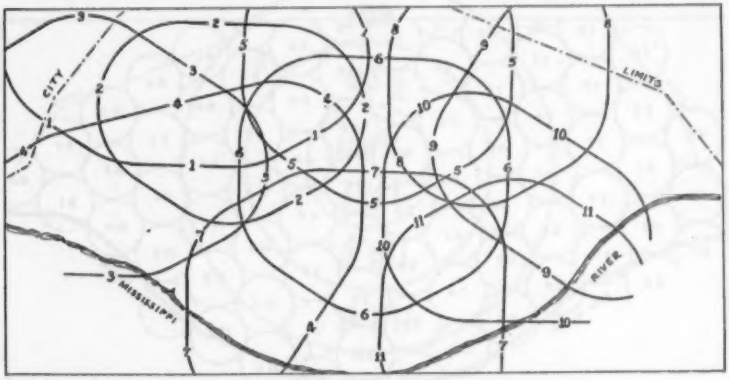
and that portion of the predetermined network of emergency traffic aidways in the vicinity.

Repeating this operation upon each of the one-mile diameter circles disclosed that the bomb-target could be moved to the centers of a cluster of from three to fourteen circles having circumferences tangent without requiring a change in that part of the aidway system that would be available individually to serve any one circle of a cluster.

Eleven such clusters, or groups of one-mile diameter circles were discovered to exist over the area of the city and this of itself determined that eleven individual traffic plans would be sufficient to serve emergency traffic requirements. The areas contained within the several clusters are designated disaster areas.

Eleven Disaster Areas

In order to define distinctly upon a master map each disaster area above developed, heavy perimeter lines were drawn, these being formed by parts of the outer circumference of the bomb-target when successively placed with its center upon the centers of each of the



This drawing is of the overlapping and interlocking perimeter lines of the eleven Disaster Areas which were generated by the use of the Bomb-Target upon various clusters of One-Mile Diameter Circles, using 35% destruction area as a measuring device in each instance.

outermost one-mile diameter circles of each cluster. For practical reasons the curved lines were joined by straight tangent lines. The several disaster areas have been designated by numbers from one to eleven, inclusive.

Following the evolution of the disaster areas, inspection was made of the highway system to serve each, and at this point modifications of the general highway framework became necessary to provide large areas, including streets and alleys, for refugee escape by vehicle or on foot, without conflict with emergency traffic on any assigned Emergency Traffic Aidway. Generally, the refugee escapeways or areas are provided to permit free flow of refugee traffic without extensive congestion, as the discharge ends are usually as large or larger than those toward any one of the disaster areas enclosed by the perimeter lines.

For each of the disaster areas the several adopted radiating streets have been designated as emergency traffic aidways to be used ex-

clusively for two-way emergency vehicular traffic. Combining the emergency traffic aidways serving each of the eleven disaster areas results in the emergency traffic plan for St. Louis.

Overlays showing each of the eleven disaster areas and the system of emergency traffic aidways serving each area have been furnished to the Office of Civil Defense and to chiefs of its operating agencies.

This drawing shows the network of city streets which were chosen as Emergency Aidways. In the main, they are a part of the United States and State of Missouri highway system.

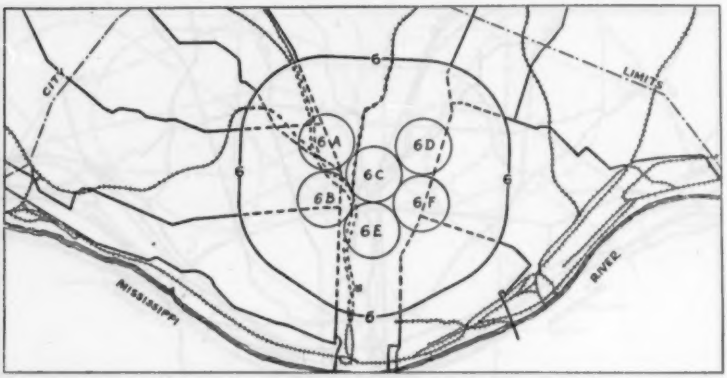
The emergency traffic aidway plan has been approved by the St. Louis Office of Civil Defense for planning purposes and is serving as a guide to the chiefs of the various operating agencies concerned in civil defense planning in connection with locating assembly areas and other temporary installations.

As an additional guide to planning, key junction points through which the separate disaster areas are interlocked and the intersecting railroads in the city have been indicated upon a separate master map.

To establish identifiable communication centers, each of the eighty-two one-mile diameter circles has been numbered and lettered to make it possible for Civil Defense Headquarters to receive prompt reports of the approximate location and extent of devastation within any disaster area.

Which basic plan will become operative in an emergency can be determined and announced only after the extent of a devastated area has become definitely known. The basic civil defense plan will provide for this decision to be made and announced to all operating

agencies immediately after the occurrence of a disaster. By reference to the basic map upon which are drawn the perimeter lines of the overlapping disaster areas, it will be possible to determine in which one of the eleven disaster areas the bulk of a devastated area is contained. The number of the disaster area thus determined will be the number of the emergency traffic plan to be put into effect. This plan



This is a drawing of the overlay for No. 6 Disaster Area showing the radiating network of Emergency Aidways which would serve this Disaster Area. The broken lines indicate that more or less of this particular portion of the aidway network would be useful within the perimeter lines of Disaster Area No. 6 depending upon where within the Disaster Area the major portion of the damage might occur.

number will be announced by using all available means of communication to Civil Defense services and installations.

Inasmuch as each of the eleven emergency traffic plans interlock with others at one or more points, it can be assumed that emergency installations located on or near any emergency traffic aidway will be assured of access to whatever disaster area may be involved in an emergency.

Where established institutions such as hospitals, motor bus garages and school buildings, to be used temporarily for emergency purposes by an operating agency, are not located directly on an emergency traffic aidway, short extensions to the emergency traffic aidway system have been planned.

The Emergency Traffic Plan for St. Louis has been published as a separate annex to the St. Louis disaster relief plan.

Planning the New Jersey Turnpike

CHARLES M. NOBLE

Mr. Noble has been the Chief Engineer for the New Jersey Turnpike Authority since May 23, 1949. He has had more than thirty years' experience in engineering in Florida, Alabama, North Carolina, Kentucky, New Jersey, New York, Pennsylvania and on advance bases in the Pacific Ocean. Most of his experience has been on highways but it also has included harbor development work, bridges, hard rock and subaqueous tunnels and naval bases. For thirteen years he was engineer with the Port of New York Authority on projects totaling $150,000,000. These projects included the Outerbridge Crossing, the Goethals Bridge, the Bayonne Bridge, the George Washington Bridge, and the Lincoln Tunnel. He also served as special highway engineer on the Pennsylvania Turnpike, highway engineer on the Pentagon Building, and as New Jersey State Highway Engineer. He won the Arthur Wellington Prize of the American Society of Civil Engineers for his paper, "The Modern Express Highway"; the Clemens Herschel prize of the Boston Society of Civil Engineers for his paper, "The Factor of Safety in Highway Design"; an honorable mention (with two associates) in an international competition for an elevated express highway design; and an honorary award from the New Jersey Society of Professional Engineers for outstanding achievement in professional engineering.

He is a member of the American Society of Civil Engineers; New Jersey and National Societies of Professional Engineers; the Highway Research Board; and the Association of Highway Officials of the North Atlantic States.

BECAUSE of the impracticability of building up quickly a large force of engineers and the desire for speed in prosecuting the work in view of the traffic congestion crisis facing New Jersey, the Authority decided that the engineering would be performed by private engineering consulting firms operating under the general direction of a small Authority staff.

To attract capital to a revenue bond project, engineering studies establish the scope and feasibility, outline the broad features of design, the estimated cost, and the traffic and revenues that may be earned by the completed facility.

The Commissioners of the Authority were confirmed by the Senate of the New Jersey Legislature and sworn in on March 31, 1949. In early May they had selected four groups of outstanding consulting engineering firms to make the preliminary surveys and reports. These firms were given the unprecedented task of making the studies and submitting completed reports within a four-month period for the proposed 118-mile cross-state Turnpike.

In determining the financial feasibility of the New Jersey Turnpike in the initial stage, design work was carried only to the extent necessary to ascertain if the Turnpike could be constructed at reasonable cost, and to make a fairly reliable estimate of cost. The designs were not refined to achieve maximum economy, nor were they sufficiently detailed for bid and contract purposes. They did not attempt to show in detail just how the Turnpike should be built.

In order to expedite final design and to initiate actual construction, the Authority divided the 118-mile Turnpike into seven sections and assigned nationally recognized highway and bridge engineering firms to design and supervise construction within the respective sections.

Final design actually began on September 22, 1949, one week after receipt of the preliminary reports which indicated feasibility. And in the final design it was necessary to obtain a tremendous mass of data quickly and evaluate much more extensively the information that had been developed during the preliminary studies. In the Fall of 1949 and early 1950, therefore, the geometric field surveys were carried to completion, boring, test pits and other soil surveys were made in detail, soundings of depths of streams, watershed data and precise locations and elevations of existing railways and highways, buildings, utilities and other topographical features were determined.

With these data in hand, the final, precise alignment was established; grades set; the depth, character, extent of foundations and the spans for structures were determined; and rates of settlement for the fills across the deep mud in the meadow lands of New Jersey calculated. With this done, contract drawings proceeded. In some cases the detailed studies for final design purposes disclosed somewhat different requirements of local governmental bodies and rail-

Here Is an Aerial View of the Lincoln Tunnel (Route 3) Interchange, Hudson County

Here Is a Typical Restaurant Facility for the New Jersey Turnpike

The New Jersey Turnpike Service Arch at Woodbridge in Middlesex County

roads than was assumed in the preliminary studies. And to this extent design and costs were modified.

Fully as urgent as the rapid production of contract drawings was completion of property acquisition maps for the 3500 parcels of land required by the Turnpike. Geometric design standards were established and issued, and for developing standard design criteria for structures, the Authority appointed a committee consisting of representatives from eight consulting engineering firms. As a result of the standards established, all of the various designers in the seven sections proceeded from the same criteria and along a uniform pattern. Form and consistency of architectural appearance of structures were developed by the Consulting Architects, Fellheimer and Wagner. This coordination of work among the several different consulting engineers achieved uniformity and economy in construction, as well as attractive design.

Standard specifications and a bid item list were developed by the general consultants, Howard, Needles, Tammen and Bergendoff, and these formed the basis for all construction contracts. In addition, the various consulting engineers for the seven sections of the Turnpike prepared for their respective contracts supplementary specifications which covered the special features of each particular contract. Contract drawings, which accompanied these two specifications, presented to potential bidders the details of the work to be done under each specific contract. The three documents thus formed the basis of mutual understanding between the Authority and the contractor with regard to the work to be done and methods of construction.

The final construction contracts, generally, followed very closely the concepts developed during the initial studies and set forth in the preliminary reports. There were modifications, however, and these resulted largely from a more accurate determination of subsurface conditions and from becoming more familiar with the requirements of other agencies affected by the construction of the Turnpike.

Negotiations with the State Highway Department, electric power and gas companies, telephone company, municipal owners of water and of sewer and other drainage lines, railroads, public bodies in charge of streets and roads other than state highways and various agencies having jurisdiction over streams and waterways, led in

many cases to final designs different from those visualized during the preparation of the preliminary designs. The Authority also prepared specifications, contract drawings, and arrangement of contracts to make maximum use of alternate materials.

Months of study and investigation were devoted to the location and design of interchanges for receiving and discharging traffic; toll lanes through which the traffic would enter and leave the Turnpike, and the toll booths and toll collection equipment, in order to assure maximum convenience and service to the public, provide for the growth of traffic, and to incorporate the most advanced ideas and engineering features.

In designing interchanges and toll facilities, it was considered advisable to prepare for substantially greater volumes of traffic than were estimated for purposes of calculating toll revenues. The estimate of the traffic and revenue engineers were believed by the Authority and its engineers to be conservative.

Accordingly, the basic traffic assumptions were increased by more than 50 per cent. The peak hourly traffic was generally considered as 15 per cent of daily average traffic. In addition to such provision in the original construction, the Authority studied methods by which these interchange facilities may be expanded in future years to care for the growth which is anticipated before the retirement of all bonds is accomplished.

In the installation of toll booths, the 1960 adjusted volume of predicted traffic was used under the above criteria. Further modifications were made based on localized studies and assumptions.

The design of architectural aspects of bridges, over-passes, viaducts, including the treatment of railings, guard-rails, lighting and signs, was based on the concept that economy and serviceability of the structures are paramount and that natural grace and attractiveness will result from expressing those requirements in simple, functional form without extraneous adornment.

The uniformity of such form and detail throughout the Turnpike is desirable, because it leads to economy and speed of design and construction made imperative by the short construction period, facilitates maintenance, and because it enables the public readily to identify any part of the Turnpike.

The outlines of bridges, abutments, piers, bents and similar features are, therefore, generally straight, with tapers or curves used only when advantageous for engineering design.

At the northern end of the Turnpike especially difficult questions of engineering and architectural design were posed by many inflexible limitations on clearances, heights, column locations and foundation conditions where crossings are in contact with other existing or proposed works, a condition inherent in passage through heavily industrialized and developed territory.

A toll project must be a complete facility providing full service to its patrons and contains certain features not required or usually contracted for on the ordinary highway. It was necessary to plan and contract for service buildings and areas for dispensing gasoline and food, toll booths, toll collection equipment, toll tickets, toll accounting machinery, two-way micro-wave radio system, right-of-way fencing, guard-rail, pavement markings, signs, lighting, maintenance and shop equipment, maintenance buildings, collectors' uniforms and roadside delineators.

Planning, designing and constructing the Turnpike has proceeded throughout in all seven sections simultaneously in accord with a predetermined schedule to assure that this facility would be made available to the public at the earliest possible date.

One-way Avenues, Re-timed Signals Improve Manhattan Traffic

T. T. WILEY

Mr. Wiley is Acting Commissioner of Traffic for the City of New York. From 1931 to 1938, he had been an Engineer in the Traffic Engineering Section of the Illinois Division of Highways. In 1938, he became Assistant Traffic Engineer in the newly-organized Traffic Engineering Department of Detroit, Michigan. In 1949 Mr. Wiley was appointed Executive Director of the Department of Traffic Engineering in New York. When the Traffic Commission was abolished and a new Department of Traffic created, Mr. Wiley became Deputy Commissioner and Chief Engineer of the new department.

A TRAFFIC improvement of major importance was accomplished in the City of New York when First and Second Avenues in Manhattan were changed from two-way to one-way operation and the traffic signals subsequently re-timed. The first step was taken on June 4, and the signal timing was changed on June 26, 1951.

The project was a move toward carrying out an overall traffic control plan for the Borough of Manhattan developed by Lloyd B. Reid, former Commissioner of Traffic, Charles S. Michalski, Engineer of Traffic Design, and the writer.

Traffic and geographic conditions in Manhattan leading to the development of the plan and its early application on First and Second Avenues are unusual. An understanding of them is necessary to grasp the implications of what was done, and why.

The geography of Manhattan is shown by Figure 1. Lower Manhattan is marked by an irregular street pattern. Midtown and Uptown Manhattan consist primarily of a grid of east-west streets, spaced twenty to the mile, intersected by north-south avenues, 400 to 900 feet apart.

This grid becomes somewhat irregular as the island is narrowed at the north, and the pattern is seriously complicated by Broadway

which starts at Union Square where Fourth Avenue and 14th Street meet. It then angles off to the northwest, creating serious traffic problems where it crosses the avenues.

These avenue crossings occur at the intersections with 23d, 34th, 42nd, and 57th Streets in Manhattan, the latter three locations being more familiarly known as Herald Square, Times Square, and Columbus Circle. These are the important two-way midtown east-west streets. They have 100-foot rights of way. The other crosstown streets in the midtown area are on 60-foot rights of way and with few exceptions are operated as one-way streets.

The Manhattan Traffic Problem

Into Midtown and Lower Manhattan pour some four million persons each day—by trains, buses, subways, taxis, and private automobiles. This tremendous activity has resulted in the signalization of 85 per cent of the intersections in Manhattan, including practically all those in the midtown area. Readers experienced in the timing of traffic signals will recognize the impracticability of two-way progressive timing on the avenues with signals at every intersection, 260 feet apart.

In order to meet this problem, the signals had been timed for simultaneous operation along the avenues. Long green periods for north-south movements are required so that traffic can move reasonable distances between stops. Accordingly, most of the signals in Manhattan had been operated on a 90-second cycle divided approximately two-thirds for north-south traffic and one-third for crosstown movement.

Unfortunately, the distribution of traffic is such that the crosstown traffic deserves a much greater share of the cycle at many intersections. Also, the spacing of the avenues is such that progressive movement east and west at a reasonable speed is impossible on a 90-second cycle. The inevitable result of these circumstances is almost complete stagnation of crosstown movements at relatively low volumes. This is the critical problem of traffic movement in Manhattan.

Other problems are also created by this method of operation.

Speeding by motorists on the avenues attempting to drive as far as possible during one green period is common. Pedestrians wishing to cross the avenues do not observe the signals because the waiting periods are too long, but dart into traffic when they think there is a reasonable gap. During periods of heavy traffic, large queues of pedestrians are accumulated on the corners, creating pedestrian congestion. The long red periods accumulate a relatively large number of turning vehicles to each cycle. Taxicabs adopt a zigzag course in order to beat the system.

Basic Control Plan

A study of these conditions made it obvious that it would be necessary to adopt a method of operation that would permit a shorter cycle in the order of fifty-five to sixty seconds. Operation on the shorter cycle, however, would make simultaneous operation along the avenues impractical. It became obvious that the signals along the avenue would have to be timed for one-way progression.

The Manhattan Traffic Control Plan is therefore based on the principle of timing the signals on a cycle to give two-way progression on the principal crosstown streets at reasonable speeds, and to time the signals along the avenues for one-way progression on the same cycle. See Figure 1.

Traffic engineers are fully aware of the principal advantages of a one-way regulation on a major thoroughfare. These advantages can be realized on most of the avenues in Manhattan, but there are several important factors that make such one-way operation difficult to accomplish on these avenues.

One of the most important of these is bus operation. All avenues from First Avenue to Tenth Avenue, except Park Avenue, are bus routes. Most routes are operated by private companies under franchises which have several years to run.

Broadway is a complication, both as to its own characteristics, and as to the traffic patterns created at its intersections with the avenues.

For these and other reasons it was decided to make the first big step on putting the Manhattan Traffic Control Plan into effect by

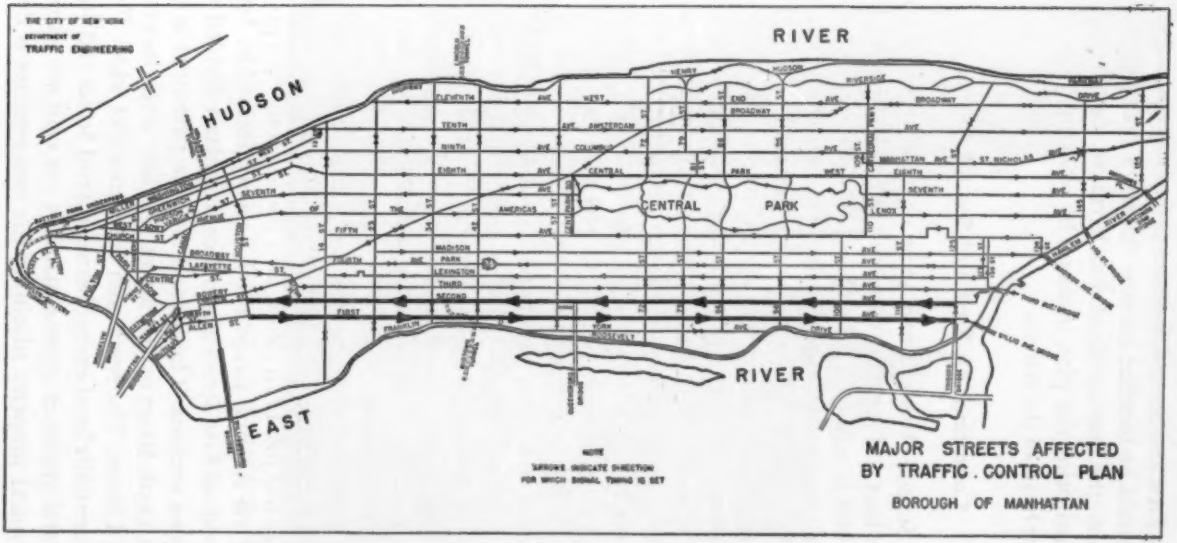

THE CITY OF NEW YORK
DEPARTMENT OF
TRAFFIC ENGINEERING
HUDSON
RIVER
EAST
RIVER
CENTRAL
PARK
NOTE
ARROWS INDICATE DIRECTION
FOR WHICH SIGNAL TIMING IS SET
MAJOR STREETS AFFECTED
BY TRAFFIC CONTROL PLAN
BOROUGH OF MANHATTAN

FIGURE 1

converting First and Second Avenues to one-way operation. The bus situation could be handled because the city's Board of Transportation operated the lines involved. Furthermore, there is considerable logic to instituting the plan in stages by working from the outside towards the heart of the system.

Conditions on First and Second Avenues

First and Second Avenues had some complications that required careful analysis and special treatment. The most important of these complications is created by the Queensboro Bridge across the East River which carries 100,000 cars a day. The main deck, which carries five lanes, makes a T intersection with Second Avenue. The upper deck of two lanes reaches the surface streets between First and Second Avenues, as do two ramps to and from the lower deck. The upper deck, incidentally, is operated to carry traffic towards Manhattan during the morning, and towards Queens in the afternoon.

A second complication is the construction at the United Nations Site along First Avenue between 41st and 49th Streets. A temporary roadway is being used along this site.

A third complication was offered by the Queens Midtown Tunnel which reaches the surface just west of Second Avenue and north of 34th Street. Still another problem existed at the south end of the system where a heavy load of traffic off the Manhattan Bridge ordinarily continued north on Second Avenue but had to be rerouted to First Avenue.

At the north end of the system, the Willis Avenue Bridge crosses the Harlem River which carried five lanes northbound to the Bronx. This bridge had just been closed for a major rebuilding project.

The First Avenue pavement is seventy feet wide, but in the section north of 81st Street a 4-foot center island divided the roadway into two sections. The Second Avenue pavement is sixty feet wide from 125th Street to 61st Street, and fifty-seven feet wide from 23rd to 3rd Street. The remainder is seventy feet wide. The topography is essentially level except between 42nd Street and 60th Street where several grades of approximately 3 per cent are encountered.

The typical property adjoining the two avenues is devoted to

Here Is a Two-way Operation on First Avenue, New York City

Here Is a One-way Operation on First Avenue, South from Queensboro Bridge, New York City

business enterprises on the first floor and to apartments on the upper floors.

Traffic counts show that each of the avenues are carrying approximately 25,000 cars a day. Of these vehicles over 20 per cent were trucks. With few exceptions, parking is permitted along both avenues. Double parking by trucks in the process of loading and unloading is common practice.

There was opposition to the inauguration of one-way traffic on First and Second Avenues. However, the two business organizations primarily involved were in favor of the proposal. Because of the debate, it was decided to make no changes in parking regulations, but only to invoke the one-way regulations and change the signal timing, so that the results would not be affected by any changes other than these two.

One-Way Operation Expedites Traffic

The change from two-way to one-way operation on First and Second Avenues took place smoothly on June 4, 1951. Brackets for the necessary signs had been erected in advance and field crews of the Department of Traffic started installation of the signs themselves at 5 A.M. The work was completed within a few minutes of the announced starting time of 7 A.M. The Police Department assigned officers to the intersections involved. At key intersections the one-way signs were supplemented by movable stanchions carrying appropriate turning regulations.

It was immediately apparent that the change to one-way operation, even without changing the signal timing, was a major improvement. The best criterion was the effect upon the time required to make a trip for the full length of the avenue.

Under two-way operation the average trip between 125th Street and Houston Street, a distance of 6 1/4 miles, required over twenty-eight minutes on First Avenue and about thirty-one minutes on Second Avenue. Under one-way operation these times were reduced to twenty-four minutes and twenty-six minutes respectively. Therefore, a 20 per cent reduction in running time was achieved.

This reduction can be attributed to two primary factors. First

and most important, was the elimination of the left turn problem. Second, driving speeds increased. This latter phenomenon was accompanied by some complaints, particularly from pedestrians, that the avenues had been turned into speedways. Thus, conversion to one-way traffic had accomplished the basic objective of eliminating some of the conditions that caused congestion, but had accentuated the speeding problem that is typical of simultaneous signal operation.

Changed Signal Timing Is Major Improvement

On June 26, 1951, the signals were re-timed to provide one-way progression on a sixty-second cycle at a speed of approximately twenty-three mph. Another major decrease in running time resulted. In addition, other significant improvements were achieved.

The average time required to make the trip between 125th Street and Houston Street was reduced to nineteen and a half minutes on First Avenue and twenty-one minutes on Second Avenue. Thus, the combination of one-way operation with progressive signal timing, reduced the time required to make the trip on these avenues by approximately one-third.

Under two-way operation the average driver found it necessary to stop every six or seven blocks for a red light, with an average of twenty stops required if driving the full distance. Under the present operation, many trips are made over the full distance without any stops. However, the average driver on First Avenue now drives thirty-nine blocks without stopping, and the comparable figure is twenty-three blocks on Second Avenue. The number of stops on the two avenues has been reduced 80 per cent. For those interested in the economics of traffic operation, the reduction in stops and delays saves about one and one-half million gallons of gasoline a year.

Under simultaneous signal timing, with all avenue signals showing green during identical periods, motorists were driving as fast as conditions permitted in order to move as far as possible before the red appeared. Speeds of thirty-five mph and higher were not uncommon. The change to progressive signal timing eliminated this problem. Motorists simply cannot drive much above twenty-three

mph for any extended distance without catching up with the red lights. On the other hand, by driving at twenty-three mph, motorists can now move along at this steady pace and have the green lights move right along with them. Observations indicate that the normal traveling speed of traffic has been reduced at least 15 per cent. Therefore, the paradoxical situation has been developed whereby traffic is being moved faster by driving slower.

It has not been possible to make an accident analysis of statistical significance. The elimination of 80 per cent of the stops should have an important impact on the incidence of rear-end collisions. One-way operation of itself reduced the incidence of accidents caused by left turns. Many readers will recognize that there are other considerations that also indicate that accidents should be sharply reduced.

Counter to this influence are two factors that are probably peculiar to the City of New York. First, the simultaneous system has been in operation for so long that many motorists had developed a habit of watching signals two or three blocks ahead, rather than the signal at the closest intersection. Consequently, there was a pronounced tendency towards running the red light during the first few seconds, and a tendency for stopped vehicles to remain standing during the first few seconds of the green while waiting for the green farther ahead to appear. Now that the system has been in operation for six months, most drivers are accustomed to the operation and the problems mentioned above have essentially disappeared.

The second important factor relates to the habits of New York pedestrians who are notorious for their disregard of traffic signals. Under simultaneous operation, pedestrians starting across near the end of the crossing green period would find a few cars stopped and would continue across in front of them when the signal changed. Under progressive timing, if they start across too late, they see a platoon of vehicles moving down upon them and therefore are under the impression that their green period is too short. It will require some time and a wide-spread use of progressive signal timing on short cycles before New York pedestrians learn how to walk safely with respect to signal indications.

Basic Plan Proved Sound

Under simultaneous timing, 71 per cent of the cycle was assigned to the north-south green and clearance periods. On the present sixty-second cycle, 58 per cent is assigned to these periods. The old timing provided forty-two and one-half minutes per hour for north-south traffic and seventeen and one-half minutes an hour for crosstown traffic. The new timing provides thirty-five minutes an hour for north-south and twenty-five minutes an hour for east-west movements. It is important to note that the improvements in traffic along the avenues were accomplished in spite of the fact that the time provided for those movements was reduced 18 per cent.

It has been pointed out that the basic problem in Manhattan is to move crosstown traffic. The signal timing changes on First and Second Avenues increased the amount of green and clearance periods per hour by 45 per cent. Obviously, this has increased the capacity of the crosstown streets at intersections by at least 45 per cent. Furthermore, the shorter cycle, by giving more frequent opportunities to move, has reduced the number of cars waiting on the red and the time that they are required to wait.

All these combined factors have practically eliminated the long lines of cars that were formerly waiting on the cross streets at the intersections with First and Second Avenues. Public attention, of course, has been focused on what happened on the avenues, but the results on the crosstown streets are of equal or greater significance, and demonstrate the soundness of the Traffic Control Plan for Manhattan.

Careful observations have been made of developments at the critical points along First and Second Avenues. Traffic from the Queensboro Bridge is being absorbed into the system much more rapidly than under two-way operation. Traffic is being placed upon the bridge as well, or better, than formerly. The situation at the United Nations is much improved over the operation under two-way traffic, in spite of the fact that over 900 cars are being unloaded into First Avenue from the United Nations garage in a quarter-hour period at 5 o'clock. Traffic from the Queens Midtown Tunnel has been greatly expedited. The terminal situation at Houston Street

was a sore spot during the first week, but changes in signing and signal operation overcame these difficulties.

No problems developed at the north end of the system that were not already there when the Willis Avenue Bridge was closed.

The center island in the upper section of First Avenue has its undesirable features under one-way operation. This is particularly true of vehicles desiring to turn left which have entered from the east and found it necessary to turn left from the right side of the island. Removal of the island would unquestionably facilitate traffic movement, but on the other hand it serves some purpose as a pedestrian aid.

Observations have shown that, even with one-way operation, signals spaced only 260 feet apart are too close together. Traffic turning into the system has no opportunity to adjust its position and speed to the signal arrangement, but is immediately stopped. This contributes substantially to the delays that remain during rush hours, particularly in the sections with upgrades where trucks cannot get up to the system operating speed within a reasonable distance.

Conclusions

Six conclusions can be drawn from the changes that took place on First and Second Avenues.

First, under Manhattan traffic conditions, a change in operation on the avenues from two-way to one-way can be expected to reduce the time required for a trip by 20 per cent, partly at the risk of higher top speeds.

Second, progressive signal timing is necessary to control speeds and, in combination with one-way operation, will reduce trip times by about one-third.

Third, under conditions of mixed traffic, operation on a sixty-second cycle with a system speed of twenty-three mph is satisfactory. Outside of business hours when commercial traffic is at a minimum, the system should be operated for higher speeds.

Fourth, the efficiency of one-way operation is reduced when signals are spaced only 260 feet apart.

Fifth, the shorter signal cycle is essential to moving traffic in

Manhattan and to bringing about pedestrian observance of signal indications.

Sixth, the basic conception underlying the Traffic Control Plan for Manhattan is sound, and the completion of the plan can be expected to reduce congestion, delays, and trip durations by at least one-third under present traffic volumes.

The general public opinion on the changes on First and Second Avenues was extremely favorable. The public believes, and the engineering studies show, that a major improvement has been accomplished. The Department of Traffic is now working out details to put the basic plan into effect in other sections of Manhattan.

Layout and Design of Parking Lots: Aesthetic Considerations

HAROLD M. LEWIS AND C. EARL MORROW

Harold M. Lewis is a consulting engineer and city planner, who has served over 25 municipalities in master plan, zoning, highway, and traffic studies. For twenty years he served as executive engineer, and later chief engineer, of the Regional Plan of New York and Its Environs and its successor, the Regional Plan Association. He is a member of the American Society of Civil Engineers and the American Institute of Consulting Engineers, and a member and past president of the American Institute of Planners. He is the author of "City Planning—Why and How," "Planning the Modern City," and several volumes of the New York Regional Plan Reports.

C. Earl Morrow is Planning Consultant for the Regional Plan Association of New York and several municipalities and counties in the New York Metropolitan Area; during World War II he was acting executive director of the Regional Plan Association. He is the immediate past president of the New York Chapter, American Society of Landscape Architects, past vice-president of the Architectural League of New York, and a member of the American Institute of Planners.

A PARKING lot can be, and often is, simply a place to get cars off the street. Many such lots have been designed with no other consideration than to crowd onto them the greatest possible number of vehicles.

When a parking lot is created as a purely temporary means of paying taxes on its site, and, if possible, to extract some profit in addition, such a policy is understandable though unfortunate. Where a parking lot is constructed as an investment or a municipal project, such a policy is very short-sighted.

Municipalities are realizing today that real parking relief requires permanent facilities and that it is a sound practice to provide some amenities of convenience, safety, comfort, and appearance to make the lots more pleasant to use. Wide aisles, ample berths, and

convenient footways, for example, result in greater ease, efficiency, and safety in entering and leaving.

Landscape and architectural treatment can add interest and a pleasing appearance to the purely utilitarian features of the layout. Such treatment includes the planting of trees, shrubs, and vines, the use of walls, ornamental signs, and other architectural features, and attractive lighting installations. All these matters are involved in the "aesthetic considerations of design" as considered in this article.

GROUPS OF PEOPLE AFFECTED

The importance of a more attractive appearance and more spacious design affects the following three groups of individuals: (1) people using the lot, (2) those living or working near the lot, and (3) the community as a whole. How each is affected is described briefly below:

Those Using the Lot

The driver looking for a place to park is primarily concerned with a convenient location, but he also wants one where his car will be safe, one he can enter and leave promptly, and in which he can both lock his car and have it accessible at all times. His initial way of judging these qualities is apt to be by the general appearance. An attractive lot with some landscaping, and even some trees to provide shade, is indicative of a well-run, efficient facility.

For the shopper, whose time is limited and who may wish to leave parcels in his car, these things are somewhat more important than for the all-day parker, executive or employee.

Those Living or Working Near the Lot

The group most concerned with the aesthetics of design are those who have homes or places of work that border and overlook a parking lot. In a large city the lot may be surrounded by a business development, but in a smaller city or village it usually is located on the edge of the business center and lies between it and bordering residential neighborhoods. This situation makes it desirable to have those sections of a lot on which cars are berthed screened from

adjoining properties by landscaped borders. The width and type of treatment of such borders will depend on the character of adjoining development; that is, a wider border would be justified alongside a high-class one-family development than against a more intensive development. Suggestions as to these details will be presented later.

Borders should be designed to protect against the glare of headlights, screen parked cars from view, and break up the noise of starting motors. Hedges and shrubbery may be effective. Fences of heavy wire mesh will prevent persons, particularly children, from entering the lot at hazardous points, or using it as a playground.

If business property abuts a parking lot and it is possible to develop rear entrances to stores, free access between the parking lot and such store space should be provided, but some low landscaping along such borders will add greatly to the attractiveness.

Community as a Whole

It has been well established that a community with an attractive system of parking lots will attract retail establishments and office buildings. Such a community will also attract residents who find that they can shop conveniently in its business center. Each of these factors redound to the great economic advantage of the entire community.

GOOD DESIGN ESSENTIAL

In the words of an old proverb: "What would be fair must first be fit." This applies as well to a parking lot as to any structure based on sound engineering design. It must be well located in relation to its patrons and its neighborhood and well designed in its provision for moving vehicles, parked vehicles, and pedestrians and its relation to its neighbors if it is to present an attractive appearance. The principal factors of design are discussed briefly below before taking up the aesthetic values that can be attained by adequate landscape and architectural treatment.

Location and Size

It has already been stated that a parking lot should be convenient to the shopping center. This means that it should preferably be

within not more than 750 feet of walking distance from stores and offices. This figure may vary between 400 and 1,000 feet with the nature of the community, a longer distance being justified in a more populous municipality.

The size of a parking lot as measured by the number of car berths may vary from 25 cars to 400 or more. In general, lots accommodating from 150 to 200 cars will be efficient and practical. A few small lots strategically situated will generally be better than one large one. In developed areas, the interior of blocks, particularly where they are 300 or more feet in width, will often be found to provide the most available and most economical sites. In new developments complete blocks may be set aside for parking, as has been done successfully in the Country Club District of Kansas City.

Entrances and Exits

Vehicular entrances and exits on side streets are better than on main thoroughfares. Pedestrian connections should, however, be provided to central points on such thoroughfares. When there is a roadway connection to the main shopping street, a one-way entrance or exit is to be preferred, with traffic regulated so as to ban a left-hand turn. All vehicular entrances should be at least fifty feet from the intersection of any street lines.

In the proposed new Zoning Resolution of New York City an attempt has been made to specify the minimum widths of access (entrance and exit) by the following regulation:[1]

Size of Parking Area	*Minimum of Access*
24 spaces or less	one 8-foot lane
25 to 50 spaces	one 10-foot lane
51 to 300 spaces	two 10-foot lanes
For each additional 150 spaces (or fraction thereof)	one additional 10-foot lane

The following principles should govern the interior design of a parking lot:

(1) Each car berth should be accessible for entrance and have

[1] "Plan for Rezoning the City of New York," a Report submitted to the City Planning Commission by Harrison, Ballard & Allen, October, 1950, page 214.

a free outlet for exit at all times and without maneuvering to get in or out of the berth.

(2) Curbs should separate the parking berths from any center islands or border strips.

(3) An adequate system of drainage should include frequent catchbasins and a minimum grade on roadways and parking areas of 0.5 per cent.

(4) Interior roadways, in large lots particularly, should provide circulation within the lot, mostly on one-way roadways.

(5) Such roadways should have a minimum width of 16 feet for one-way diagonal parking (permitting two cars to pass in an emergency) and 20 feet for two-way roadways serving diagonal parking. Right-angle parking requires a minimum of 20-foot for one-way roadways with back-in parking, and 30 feet for two-way roadways or head-in parking.

(6) Protected walkways for pedestrians are generally desirable in lots accommodating 150 or more cars.

(7) Suitable islands should be provided for trees, ornamental planting, and the location of light standards.

(8) The lots should be paved with a dustless surface.

(9) Border strips should be provided to allow for the overhang of cars heading into the berths, landscaping, walks, or other treatment.

(10) Consideration should be given to space for snow storage or removal in climates where this may present a serious problem.

(11) Suitable locations should be provided for the installation of parking meters, which are an increasingly popular means of financing parking lots.

In designing marginal strips, an allowance of two feet should be made for the overhang of car bumpers over the curbs. Such overhangs will probably average about 1½ feet where cars head into berths, and more where they back in.

If only a hedge is to be added to a marginal strip, the minimum distance from the curb to the property line should be about four feet. If the hedge is to be supplemented by other planting, five to twenty feet, depending on the character of adjoining development, will be needed.

If a lot is opposite a residential area, a 15-foot landscaped border along the street side will provide an effective screen. In one such case in Garden City, N Y., a 75-foot strip was landscaped to conform with the setback of adjoining dwellings.

Where a walk is located between a row of parking berths and adjoining business property, a minimum width of 5½ feet will be desirable; about 1½ feet of this, as explained above, would be taken up by bumper overhang.

Where walkways are provided between rows of parking berths, the minimum width should be six feet, which would leave only about three feet between overhanging bumpers. If space is available, particularly if parking meters are to be installed thereon, a somewhat wider walk would be desirable. A seven-foot walk will accommodate a row of shade trees or a light standard in its center.

Such walks will not be used extensively by pedestrians unless they run in the normal direction of travel, that is towards entrances, exits, or stores. In one employee lot, an eight-foot mall between parking bays was planted with trees and ground cover instead of utilizing it as a walk.

USE OF ZONING

Zoning regulations can be used as a means of assuring aesthetic characteristics in parking lots provided as accessory to business uses, as commercial parking lots under private ownership, or as municipal parking lots. Such regulations can specify:

(1) The minimum distance between parking berths and side or rear lot lines.

(2) Minimum setbacks of parking areas from street lines (for example, in Garden City, New York, they are subject to the same setback requirements along residential side streets as are the residential buildings).

(3) Landscaped treatment or ornamental walls along borders.

When a parking lot is subject to a special permit by the Board of Appeals, the Board may require other details in specific cases as safeguards to neighboring properties and the general public.

Some form of transition zoning may be employed to facilitate

Ornamental Treatment of the Pedestrian Entrance to an Accessory Parking Lot.

Combination of Wall, Trees, Shrubs, and Flowers Gives a Garden-like Appearance.

Combined Entrance and Exit to Lot

Four Feet Wide, Right-angle Parking

Both Trees and Light Standard

A 5-foot Landscaped Border and Fence

Trees Sacrifice Little Parking

Here Cars Overhang the Curb

A View in Garden City

A Dual Standard in a Terminal Island

the construction of parking facilities in the rear of retail establishments and between them and adjoining residential districts. In some cases strips of land in such locations have been zoned to permit their use for parking only, but, while this may prove practicable in new development on vacant land, it creates serious problems when applied to existing communities.

LIGHTING

Municipal parking lots should generally be designed so as to serve both day-time and evening patrons, the latter including customers of movie theaters and other places of evening assembly. It is therefore very desirable to have them lighted. This will both aid in policing against pilfering and molestation of customers and improve the attractiveness of the lots. The latter brings up two aesthetic considerations: the kinds of light standards to be provided, and whether wiring is to be overhead or underground.

If the parking lot borders a residential neighborhood, underground wiring and attractive standards will be justified as adding much to the appearance. If it is surrounded by business properties these may be considered extravagances but are still desirable.

In many cases, the installation costs of standards as well as of wiring are provided by the electric utility company and financed by annual payments by the municipality, thus avoiding capital expenditures for this part of the project.

LANDSCAPE TREATMENT

With the general objective of making the parking lot a pleasant place for people to use and view, the planting of trees, shrubs and other vegetation offers extensive possibilities. In order that these opportunities may not be lost or severely limited the space required must be considered in the early stages of the layout.

However, a landscape treatment consisting only of the addition of vegetation as decoration to the parking lot has limited chances of producing a satisfactory result. As in the beauty of a bridge or building, the arrangement of mass, area, form, and line are aesthetically

important. While many of these factors are fixed by utilitarian objectives and requirements there is often opportunity for adjustment to produce better looking results. The subjects of walks, fences, entrances, and light structures have been discussed above as being closely related to engineering design. Other items which are essentially landscape treatment are discussed below.

Use of Shade

One of the practical purposes of planting is to furnish shade. Broad expanses of pavement exposed to the summer sun become unbearably hot and automobiles with their windows locked become veritable ovens. A canopy of trees at least partly covering the parking lot can reduce materially the discomfort to people if not actual damage to the cars.

The shade that may be listed as an asset in the summer season would become a liability in winter as it would delay the melting of snow and ice. If for no other reason than this, most of the trees should be deciduous rather than evergreen, except perhaps along the northerly boundaries of the parking lot where they would not throw shadows on the lot and would at the same time trap some of the sun's rays to increase the temperature within the lot.

Treatment of Borders

Another practical use of planting is to screen out undesirable views from the parking lot or, reversing the process, to screen the lot from the view of adjacent development. If a park-like character is established and maintained in the lot, a complete screening from abutting development would not ordinarily be necessary.

Many of the best sites for parking lots in central areas are in the interiors of large blocks. In most cases the rear walls of commercial buildings, or of poorly maintained dwellings waiting to be replaced by business buildings, cannot be regarded as having an aesthetic appeal. The renovation of the rear walls and yards of such buildings is generally impractical to attempt. Masonry walls have been placed on the borders of parking lots in several cities, providing a complete screen only to the height of the wall. While appropriate under some conditions, initial cost and, if the wall is high, the blocking of air

circulation, tend to disqualify them as a general solution of the problem. The use of planting alone or in combination with a wall or fence can overcome some of these limitations.

On the other hand, walls are considered necessary for commercial parking lots in residential areas by several cities. From 107 replies to a questionnaire, the Urban Land Institute reports that "Sixteen cities have recognized the importance and necessity of screening to protect adjacent residential development by requiring both screen planting and a wall or fence at the boundaries of the parking area. In most cases wall heights are specified, varying from three to six feet. Four cities require a wall or fence only. In most cases a solid masonry wall is specified."[2] Even where walls are required as a border enclosure, it is usually desirable to supplement them with certain types of planting.

Beyond screening out undesirable views from the parking lot, border planting functions as an enclosure which tends to unify the whole design. Where views of the outside are assets to the character of the lot the border planting can be less dense and even used to frame such views.

Space Requirements

For the purpose of shade, screening, and enclosure the principal space required is a strip of land surrounding the lot, supplemented, in the case of large parking lots, by planting islands between some of the rows of the parking stalls. How much space to allow depends on a number of factors. Plants need unpaved earth to expand their root systems underground as well as air space above ground in which to grow.

In densely developed central areas where land values are high it would seem reasonable to skimp on the area assigned to planting. Walls and fences and special plant material requiring a high maintenance cost can then be resorted to. In less densely developed districts a more generous allotment is appropriate. Depending on whether the objective is merely shade, or partial enclosure, or complete year-round screening, the border strip should, as already

[2] "Commercial Parking in Residential Areas," Technical Bulletin No. 9, Urban Land Institute, 1737 K Street N.W., Washington, D.C.

pointed out, have a width of between five and 20 feet. For commercial parking in residential areas, parking should not be permitted between the street line and the residential building setback line.

Landscaped islands between rows of parking stalls having pavement impervious to water should be not less than six feet wide, the minimum also recommended if they are to be paved for walks. With a curb which stops only the wheels of the cars, the loss of parking space when 60 to 90 degree parking is used, is not serious as the overhang space does double duty. Other features in a parking lot may require, for aesthetic reasons, a certain amount of extra space. For example, it may prove desirable to accentuate an entrance or frame a view to a public building with special plant material.

PLANTING DESIGN

The plantsman has available in most sections of the country a wealth of material the characteristics of which may be grouped under the headings of form, texture, and color. In the selection and arrangement of plants a consideration of these characteristics, along with practical matters related to their growth, will in a large measure determine the success of the planting from an aesthetic point of view.

Trees and shrubs, when growing singly, assume characteristic forms and sizes. Some approximate geometrical shapes, such as spheres, cones, and cylinders. Others are completely irregular, and still others present all kinds of combination of form and lack of form. Harmony, variety, contrast, and accent can be secured by the selection of plants for their form. One of the more common contrasts of form consists of a low round plant in juxtaposition with a tall spiky one, not unlike, in form but not in scale, the trylon-perisphere architectural feature of the New York World's Fair of 1939. Similar form contrasts appear in oriental architecture with dome and minaret.

Texture

The size and shape of leaves, the way they are attached to the twigs and branches, and the density in which they occur combine to produce visual effects which may be described as texture. As in cloth

texture this may be fine or coarse, or any gradation between. The peculiar branching may produce patterns in the texture such as the stratification made by certain horizontally branched plants. In winter the deciduous plants have a texture resulting from their system of branching. As in the case of form, plant texture affords opportunities for harmony, variety, contrast, and accent.

Color

The mention of color of plants probably brings to the minds of most people the nearly complete spectrum of vivid colors of flowers. Blossom time for most plants, however, is comparatively brief. The leaves which remain all summer or throughout the year have a wide variety of colors. Besides all shades of greens and the yellows and reds of autumn, some plants afford special leaf colors throughout the season, such as reds, purples, blues, and yellows.

A more subtle coloring, but none the less real, is found in the bark of trunks, branches, and twigs. In fact the principal ornamental value of some plants lies in the winter coloring of the bark.

Planting Plan

With the availability of wide variations in form, texture, and color in plants the opportunity for applying principles of aesthetic organization is ample. To one inexperienced it may seem bewildering with no clue as to where to start. An approach likely to succeed consists of determining the characteristics desired in the plants at specific locations and making selections that most nearly measure up to what is wanted.

No rule of thumb can be devised to insure an outstanding result. A suggestion that may be helpful is to hold one of the many variables constant for the sake of unity or harmony, and count on a diversity in the other variables for variety. Another is to determine initially a dominant motive or characteristic such as a neat or trim appearance or its opposite, a rugged and picturesque appearance, making plant selections according to whether they conform with or act as a foil for the dominant motive.

Enough has been said to indicate the complexity of the procedure of securing an aesthetic organization of plant material. Lest it appear too forbidding it should be pointed out that every plant

generally used for ornamental purposes has a beauty of its own which cannot be completely discounted in any combination of plants. A parking lot with planting of most any description is so superior in looks to one without planting that an inability to secure an outstanding result is not a valid reason for failing to provide planting.

Practical Limitations

The number of types of plants appropriate for the parking lot is reduced considerably because they are unable to withstand urban conditions or require excessive maintenance or create other problems.

Many plants which would otherwise qualify for the parking lot must be discarded because they would not survive or grow to a healthy maturity because of unfavorable soil or atmospheric conditions of the city. Helpful information on this subject can be obtained from park departments, shade tree commissions, university horticultural departments, and local arboretums. An inspection of the types of plants in the neighborhood of the parking lot is also suggested.

The amount of maintenance required is an important consideration in the types of plants used. Some trees are undesirable because their lower limbs have to be pruned or they produce fruits that have to be cleaned up or have an overabundance of leaves. Clipped hedges should be considered in the light of the maintenance required. Even turf panels may be expensive to maintain because of constant cutting or replacement if subject to foot wear. Flowers, whether perennials or annuals, need constant care. In fact they are so expensive to maintain that it is better to exclude them as a general rule, counting on shrubs and trees to furnish bloom. Vines, useful for screening on fences, decoration on walls, or as ground cover, require a small amount of maintenance.

Other problems arise from the use of fast-growing brittle trees subject to damage and creating damage from wind, ice, and snow loads. Also the root systems of some trees tend to clog sewer mains and the branches of some may conflict with telephone and electric wires and lighting systems.

PLANT SUGGESTIONS

Perhaps the two most important growth factors in a plant list are whether or not they are hardy in the local climate and whether or not they require an acid soil. The proper spacing of plants is also important to enable them to grow to maturity either as single specimens or as merged groups. The following sample list is suitable generally for the New York metropolitan section of the country.

ILLUSTRATIVE PLANT LIST

Deciduous		*Evergreen*	
LARGE TREES			
Platanus orientalis	European Plan	(None of the fine-needle trees are generally suited to industrial city conditions)	
Quercus palustris	Pin Oak		
Tilia vulgaris	European Linden		
Ginkgo biloba	Maidenhair Tree		
Ailanthus glandulosa	Tree-of-Heaven		
SMALL TREES			
Crataegus (in variety)	Hawthorn	Ilex (in variety)	Tree Holly
Sorbus aucuparia	European Mountain Ash	(Often listed as large shrubs)	
Koelreutaria paniculata	Goldenrain Tree		
SHRUBS			
Berberis thunbergi	Japanese Barberry	Ilex (in variety)	Holly
Ligustrum (in variety)	Privet	Taxus (in variety)	Yew
Acanthopanax pentaphyllum	Bush Aralia	Pieris floribunda	Mountain Andromeda
Euonymus alatus	Winged Euonymus	Kalmia latifolia	Mountain Laurel
Lonicera (in variety)	Honeysuckle	Leucothoe catesbei	Drooping Leucothoe
GROUND COVER			
Lonicera japonica	Vine Honeysuckle	Pachysandra terminalis	Japanese Pachysandra
Rosa wichuraiana	Memorial Rose	Hedera heliz	English Ivy
		Vinca minor	Periwinkle

ACKNOWLEDGMENTS

Part of the illustrations in this article was supplied by the Department of Public Works, Village of Garden City, N. Y., and by J. C. Nichols Company, developers of the Country Club District, Kansas City, Mo. The other photographs were taken by the authors in typical parking lots.

Street and Traffic Management: A New Approach

MAYOR ALBERT E. COBO

Mayor Cobo, widely known as a producer of efficient business methods in city government, served as deputy city treasurer and later city treasurer in Detroit for fifteen years. He modernized tax collections and other procedures. As chairman of the City-County Building Authorities, he became a prime mover in Detroit's river front development. Mayor Cobo conceived and carried through the financing plan to accelerate expressway construction projects. By borrowing against vehicle tax revenues, his plan, barring war delays, will complete the Edsel Ford and John Lodge Expressways in approximately four instead of the anticipated fourteen years.

HAVING put America on wheels, Detroit traditionally has been expected to lead the way in the safe and convenient use of the automobile.

The Motor City pioneered many of the innovations for traffic efficiency and safety now common wherever people and goods move in rubber-tired vehicles. Said to be the first city in the world to use traffic signal lights, it later developed the three-color light, standard throughout the United States.

White center lines were "premiered" on Wayne County highways in 1911, and in 1916 Detroit carried the idea further by painting the first street lanes and pedestrian cross-walks. The prototype of the safety zone to protect passengers boarding and leaving streetcars was built on Woodward Avenue in 1921. Currently Detroit is trying out a new fluorescent street-lighting installation, first of its kind anywhere.

Detroit has helped to set the pace, too, in modern methods of selective enforcement and safety education. Our famous "Drunk Drivers Go to Jail" program has created wide interest across the nation.

By the same token, our recently completed study, "Meeting the Crises of Street Transportation in Detroit," represents a distinct

contribution towards solving urban traffic problems. Certainly it provides a challenging approach in the key area of street and traffic management. Opening our congested cities for free movement of vehicular traffic—in the face of generally antiquated street plans and record-breaking travel volumes—poses a supreme test of sound management.

The traffic tribulations of cities stem not from too many automobiles, but from too few adequate motorways. We know that for something like three decades, while the bulk of public road funds was channeled into rural highway construction "to get the farmer out of the mud," little thought was given to getting the urban motorist out of the growing traffic muddle. A depression, a world war and now a defense emergency of probably long duration have tended further to keep the brakes on urgently needed capital street improvements. So the urban arteries have become the critical bottlenecks of the nation's highway transportation network.

The mayor of any sizeable city can reach into the dusty pigeonholes of the municipal archives and pull out any number of traffic reports of years gone by, all repeatedly warning that something drastic must be done to relieve the street congestion problem. I recall a report dating from 1924. It stated bluntly: "Detroit is being strangled for lack of sufficient circulating facilities for its people."

The ironic thing is that since the early Twenties, traffic volumes have multiplied six or eight times; trucks and buses, then a rarity, have become a major factor in the traffic stream; and yet we are trying to crowd them all onto street systems which have remained relatively unchanged since horse and buggy days.

Basically, neither the street patterns of our cities nor the utilization of their land areas are in harmony with the use of the motor vehicle as a principal form of transportation. The case of Detroit offers a good illustration.

Detroit's street system is built around six radials, originally constructed as military roads to connect Fort Detroit with other garrison points. Later these radials were extended to serve as the community's main thoroughfares, converging on the central business district. Since the Detroit River forms a natural barrier to the south, the subsequent development of the street plant—with the city eventually

embracing 144 square miles—was all to the west, north and east. This accounts for the fact that getting downtown involves unusually long trips. It also complicates the problem of distributing downtown traffic with any degree of efficiency.

While in the earlier stages of the city's development these spoke-like arteries, leading to a single concentration of population, amply supplied all transportation needs, it was a different story as the community began to spread to metropolitan proportions. The radial plan did not provide suitable connections between the numerous industrial and commercial centers that sprang up in the outlying districts.

Crosstown traffic is therefore forced to pursue devious courses through narrow streets to get from one main artery to another; and because of lack of bypass, large numbers of vehicles, with no purpose in the downtown area, swarm there just the same because at present there is no more feasible route.

Meanwhile, the satellite centers of business and industry, likewise rigidly tied to the radial system, are experiencing some of the same traffic difficulties as the downtown district.

Aggravated Street Congestion

Detroit's large area and its relatively low density of population discouraged the development of rapid transit facilities such as serve other large cities. On the other hand, the distance between the homes of many of our industrial workers and their places of employment result in the additional use of private cars. Upwards of 70 per cent of Detroit workers drive to and from the jobs in their own automobiles, many of them twenty to thirty miles a day.

In the light of these factors, it is easy to understand how our street congestion problem was aggravated with the influx of some additional 375,000 workers during World War II. Traffic volumes at many specific locations rose nearly 100 per cent above peacetime figures. Many minor streets began duty as major arteries because of their proximity to new war plants. But for the restrictions on gasoline, tires and automobile manufacture, conditions doubtless would have become intolerable.

One of the main lessons of the period was the demonstration of the utter dependence of war production on the motor vehicle. The trend of industrial plant dispersion was sharply stepped up, necessitating more and more reliance on the automobile. Availability of manpower and materials was virtually conditioned on motor transport.

In a real sense, streets in Detroit are part of the assembly lines. Factories count on motor vehicles to maintain a steady flow of materials, parts and sub-assemblies from numerous supply sources to a single point of final assembly. Delivery of thousands of items at the plants on closely-timed schedules hinges on prompt and unimpeded highway movement.

This vital relationship between motor transportation and Detroit's output, in peace as well as in war, explains why our metropolis is one of the most heavily traveled urban sections of the world. Traffic counts, for example, have shown that on a single day more than 85,000 motor vehicles move through one Detroit street intersection—at Grand Boulevard and Grand River Avenue.

At the approach of V-J Day, we estimated that as travel restrictions were lifted and new cars became available, traffic volumes in Detroit might rise 25 per cent above the all-time high of 1941. By the end of 1950, however, an increase of 33 per cent had already been recorded, and volumes are still mounting at the rate of about 7 per cent a year. It is significant that while the last census revealed that the Detroit area made a 20 per cent gain in population in the past 10 years, motor vehicle registrations soared 36 per cent during the same period.

These, in brief, are some of the components in Detroit's long-time traffic problem; and over the years, in the Motor City as elsewhere, congestion, lack of off-street parking and related traffic ills have exacted heavy penalties.

Congestion's Cost in Man-Days

Our City Plan Commission, estimating losses in addition to life and limb, said in 1942: "Attributable to traffic congestion and delay last year was the loss of four million man-days of work. Also ascribable

to the inadequate, unfunctional street system was immeasurable property damage resulting from the blighting influence of heavy traffic forced to stream through residential areas for lack of other channels of movement. The toll: $30 million for accidents, $25 million for delays, countless millions for property damage—a loss of over $125 for every family in the city."

Traffic Improvement

Detroit by no means has been inactive in trying to improve traffic conditions. Our Traffic Engineering Bureau has been carrying forward an aggressive and up-to-date program of operational measures such as curb-parking controls, turn prohibitions, one-way streets, channelization and signal modernization.

Recently we obtained state legislation to expedite the financing of a basic expressway system. The city has one of the best and most enterprising safety organizations in the country, strongly supported by civic groups and public officials. I have already referred to the notable enforcement work of our police and courts.

In view of the greatest travel volumes in our history, and the tremendous responsibility re-imposed on Detroit because of current defense requirements, I thought it wise to take stock of our entire street and traffic management structure and operations. The object was, by means of an impartial investigation, to appraise the actual status of our street transportation system; to evaluate the work and responsibilities of the various departments involved; and to thoroughly explore inter-departmental relations—all to make certain that we were doing the most effective job possible within budget limitations.

To this end I obtained the aid of the Automotive Safety Foundation, which made available the services of D. Grant Mickle, head of its Traffic Engineering Division, to direct the study. Fortunately, Mr. Mickle was intimately familiar with the city's traffic problems, having served as Detroit Traffic Engineer in the early 1940's.

The timeliness of the project was pointed up by the coincidence that October 9, 1950, the day Mr. Mickle arrived for preliminary dis-

cussions, was marked by the worst traffic jam in Detroit annals—a rain-generated nightmare that stalled all movement in the downtown area for hours.

To supervise this proposed survey of administrative and physical needs, I appointed a Traffic Advisory Committee consisting of City Controller John H. Witherspoon, Chairman; Donald Slutz, Managing Director, Detroit Traffic Safety Association; and Richard Harfst, General Manager, Automobile Club of Michigan. The Committee worked closely with Mr. Mickle and other Foundation staff members during the course of the six-month study. The published report was put into the hands of the Common Council on May 24, 1951.

The findings and recommendations with respect to administrative improvements are particularly important, and I want to outline some of them here because I know they will be of interest to other cities.

While the report specifies numerous physical improvements which demand prompt attention, it emphasizes that sound reorganization of the administrative structure is the keystone for a more effective overall program of traffic relief. Thus the pivotal recommendation is to consolidate all essential functions of street and traffic management, centralizing them by Charter amendment in a new Department of Streets and Traffic.

To quote the report: "Forthright and resultful action on the city's traffic problems requires streamlining of administrative procedures, with full recognition of the vital importance of street and traffic management as a major municipal function. This phase of municipal activity, born only a generation ago, has grown up more or less haphazardly. It has not been soundly organized, nor has it been given the attention and stature accorded to older city functions, such as water supply, welfare, public health and safety. . . Management, instead of being centered in one department with a specialized background in street and traffic matters, is dispersed among many agencies—many of them concerned with traffic only as a sideline."

The Detroit Charter makes no provision for such coordination of responsibilities and authority. Over the years, as problems have arisen involving duties in the traffic area, they have been met by

various ordinances, executive orders and administrative practices. Because of this random development, responsibilities are now diffused among some fifteen different municipal agencies.

An indication of how scattered these duties have become is the fact that before a sound analysis of administration could be made, it was necessary to undertake a special legal survey "in order to disentangle and identify them"—to use the words of the report. This and other legal aspects of the management study were handled by Louis R. Morony, head of the Foundation's Laws and Ordinances Division.

Under the suggested reorganization, the many agencies having collateral activities in street transportation would be reduced to five, including the Mayor and Common Council.

In the new Department of Streets and Traffic would be grouped all functions of street construction and maintenance, traffic planning, street operations, parking and electrical engineering pertinent to traffic signals. Directing the department would be a four-man commission named by the Mayor, with terms on a staggered basis to insure continuity of policy.

The proposed plan calls for a General Superintendent, serving directly under the Commission, to have charge of two main branches under which all functions would be organized—a Bureau of Streets and a Bureau of Traffic. Each bureau would be headed by a chief engineer, fully qualified in his special field.

It is recommended that duties and personnel be transferred to the new department from the present Traffic Engineering Bureau and the Municipal Parking Authority, and from divisions of the Department of Public Works and the Public Lighting Commission. Integration of functions would eliminate the need for the existing Traffic Committee.

Staffing the department could be accomplished almost entirely by shifting technical and clerical personnel and labor force from agencies now performing these duties. "Combining of like activities in the centralized agency would serve to increase efficiency, permit optimum use of the labor force and expedite the work program," the report declares.

Such an integrated department offers the best means of properly

coordinating and correlating physical street improvements and traffic operations, the report emphasizes; and I should not be surprised if officials of other cities may feel that here perhaps is the fundamental clue for attaining the degree of managerial efficiency demanded by today's complex traffic problems. To my mind, the great virtue of this proposal is that it would combine the *planning* and the *doing* in a single agency.

For, as the report adds, "only with such a close-knit structure—with each function receiving full attention of technical specialists in that function—can departmental delays, frictions and inefficiencies be held to a minimum. Only through centralized budget can projects be carried forward according to priority of need, with the sole aim of affording the taxpayer the best possible transportation service for every dollar spent for street facilities."

Immediate Needs

Among the immediate physical needs to which such a new Department in Detroit should direct its efforts, the report lists: stepping up of the expressway program; widening of a number of major arteries; maximum use of traffic engineering techniques to insure the utmost possible service and safety on existing streets; citywide modernization of traffic signals; and rigid enforcement of parking regulations, in conjunction with an adequate off-street parking program.

Many of these and other recommended betterments have been advocated for years. In fact, some were proposed by Mr. Mickle when he was Detroit's traffic engineer nearly a decade ago.

The study director points out that although traffic engineering can create significant benefits through technical expedients, yet in the end there is a limit to the volumes the present streets can handle. We find in Detroit, for instance, that conversion of thoroughfares to one-way operation seldom increases capacity more than 30 per cent; and it is unlikely that even perfectly working curb-parking controls would long offset the constant growth of traffic.

Clearly the chief hope for lasting relief lies in the expansion of capacity through capital improvements. With the exception of

widenings on Michigan, Gratiot and Woodward avenues completed in 1941, and now a beginning on expressways, no major improvements have been made in Detroit's streets for over twenty years.

However, we expect more rapid progress on our expressway system in the near future. Work is proceeding on the north-south John C. Lodge route and the crosstown Edsel Ford route. An agreement providing for the completion of these high-type facilities was jointly entered into last April by the City of Detroit, the Wayne County Highway Commission and the Michigan State Highway Department.

This may make possible full use of these two expressways within five years. Estimated cost of the balance of the present program is $134 million, with a financing plan contemplating an $80 million bond issue. The first three-mile section of the Edsel Ford Expressway was opened up on July 9, 1951.

I am confident that the public, once having experienced the advantages and convenience of the expressways, will not only demand more of them but will more vigorously support official action to push the program. These facilities will eliminate much of the purposeless and illogical travel that is now clogging the downtown area. Moreover, they will supply the additional street capacity which Detroit needs so desperately. As Mr. Mickle emphasizes, many of our major arteries have reached their traffic saturation point, and a rain storm, an accident, or even a slight increase in traffic volume can cause virtually complete stoppage.

On the physical side, we also expect substantial increase in street efficiency through our current traffic-signal program, the most extensive ever undertaken in Detroit. This three-point plan includes (1) installation of new signals wherever needed; (2) visibility improvements at existing installations to provide adequate signalization for both motorists and pedestrians; and (3) replacement of obsolete signal control equipment with modern controllers for better signal timing and greater flexibility of operation.

The Mickle report also contains an interesting proposal with respect to the parking problem. It recommends the full integration of all official parking activities, including control of curb parking, meters, licensing of commercial lots, and the planning, design and

location of off-street parking facilities. In line with the advocated consolidation of traffic management functions, the report observes, an opportunity is presented for the first time to coordinate all phases as elements in a citywide parking system.

Allied to this proposal is the suggestion that consideration be given to the establishment of one or more consolidated truck terminals, so as to reduce travel and loading and unloading of commercial vehicles on the streets.

Another recommended step, designed to help reduce accidents and traffic confusion, is to review the Detroit traffic ordinances, "with the objective of modernizing, clarifying, and bringing them into harmony with the nationally recognized standards."

Finally, to provide a sound factual basis for planning the overall street improvement program, the report urges an area-wide origin-and-destination study. The report points out that many metropolitan centers in the United States have found this type of survey invaluable for determining present traffic patterns and future trends—in other words, providing a truly composite picture of the traffic situation on an area-wide basis.

The concluding words of the report, though directed specifically to Detroit, can be paraphrased with equal applicability to other major cities: "The program charted here is a blueprint for doing a progressively better job in the provision and operation of street facilities. Resolutely applied, it will help to realize more completely the economic and social benefits of the motor car, and by the same token, foster the progress and prosperity of the city."

I am glad to say that the Detroit Common Council has already taken action to implement the report recommendations, at least in part. It approved a proposed Charter amendment and the people of Detroit overwhelmingly voted the adoption. This amendment provides for setting up a Department of Streets and Traffic. While the consolidation called for in the amendment does not include the construction phase, and falls short in two or three other respects from the overall plan advocated in the report, we feel it is a definite step in the right direction.

The proposed amendment gives traffic engineering the dignity and importance of chartered status. The new department in addi-

tion to its traffic engineering functions, would have paramount control over matters affecting traffic, including the establishment of standards and priorities for the work of other departments concerned with traffic. This should immeasurably improve the handling of highway transportation problems in Detroit.

Because I believe that the Mickle study constitutes an intelligent and forward-looking appraisal of traffic problems common to all larger municipalities, I have personally forwarded copies to Mayors and City Managers of many cities throughout the country. It seems to me to open up new avenues for upgrading one of the most vital areas of present-day public administration, and thus sets an objective toward which all cities should strive.

The 'Yield-Right-of-Way' Sign

PAUL W. RICE

Mr. Rice has been City Traffic Engineer of Tulsa, Oklahoma, since May, 1949. Prior to his appointment, he had worked for the Oklahoma City Engineering Department.

THE urban intersection confronts traffic officials with problems of many kinds. Some of these problems come from physical conditions on and around the intersection. Others arise from the conflict or impending conflict of vehicles and pedestrians.

The standard Stop-sign has long been the first answer to the need of the intersection. The two-stop installation has been considered the minimum traffic control where relief is needed and safety to cross-traffic and pedestrians is the desired result.

For a while, a few years ago, critical speed limits were posted at some intersections as a guide to drivers. Often the driver would find it hard to observe the exact speed at the same time he was dealing with cross-traffic and other intersectional conflicts.

After weighing the results and effectiveness of many of the stop and critical speed sign installations, traffic engineers throughout the country started searching for an intersectional control sign which would be less restrictive than the stop sign, yet would definitely and positively establish the right-of-way.

The question was often asked by engineer, police officer and lay driver alike, why should all vehicles be forced to cease movement at every stop sign—regardless of the presence of cross-traffic? Police traffic officers vary in their opinion as to the need for every driver to come to a complete stop at all stop signs. This fact, coupled with the report that officers were arresting drivers only when an accident occurred after passing or "rolling" a stop sign, prompted the experiment with the new YIELD Right-of-Way sign in Tulsa.

The YIELD sign, Figure 1, is not to be considered as a replacement for the stop sign. In many cases, however, it is a worthy substitute for the previously over-used stop sign. It is applicable to locations where the view is obstructed, where through-movement

is unsafe, and at many other locations where accidents continue to occur but traffic volumes are light.

The YIELD sign cannot be used to supplement a two-way stop installation, as the two types of control would be in conflict. It can be used at almost any open-type intersection as the first type of traffic control applied to the intersection.

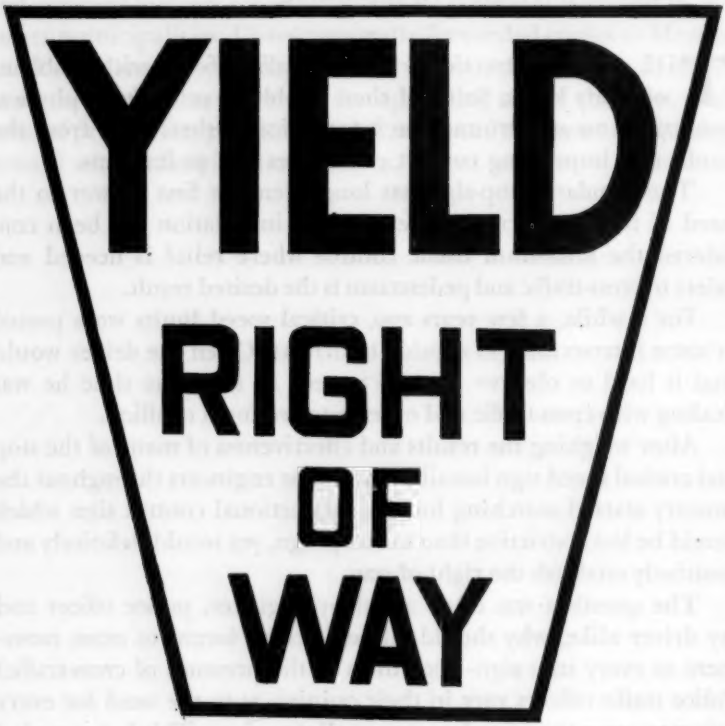


FIGURE 1

Origin and Design

The YIELD Right-of-Way sign can hardly be considered as a "Tulsa Original," as the advent of a control of this nature has been discussed and tried almost annually in recent years. Tulsa is proud to have had a part in pushing a sign of this type through to the

stage where several installations have been made since January 1951. The need for such a sign was realized by the officials of the City of Tulsa. The problem then was to design the sign to convey the desired message and obtain the legal right to use it in Tulsa.

The traffic engineer, along with Captain C. E. Riggs, of the Tulsa Police Department, designed the sign and decided upon the wording, color and letter size. The design, size, script and color came only after much study and experimentation. Several traffic experts over the nation were also consulted as to our design, size, shape, wording and color. Without exception, the comments and appraisals have been favorable.

The YIELD sign was designed as a wedge or trapezoidal shape because of the distinctive design. This shape also lends itself well to cutting from one continuous piece of metal with a minimum of waste. The sign is two feet high, two feet across the top, and one foot across the bottom. The lettering is standard for highway signs and is black on a traffic yellow background.

The letters in YIELD are seven inches high with a one-inch stroke, the words RIGHT and WAY are three and one-half inch letters and the word OF is two and one-half inches in height. The design balances well on the sign with a 3/8 inch border one-half inch from the edge of the sign. The experimental signs were made in the Traffic Engineering Department Sign and Paint Shop, Tulsa.

Legal Authority

The authority to install the YIELD signs in Tulsa was granted by the mayor and the board of city commissioners. The Traffic Engineering Department, to which is delegated the authority to install and maintain traffic control devices, was then in a position to proceed with some experimental locations. The Traffic Engineering Department then set approximately forty YIELD signs at open intersections over Tulsa.

When the Traffic Ordinance was revised and approved in March 1951, there was a reference to the YIELD right-of-way sign. Under the heading of OPERATION OF VEHICLES, Article VII, Section 47, *"Stop at Entrance to a Through Street* (47g)." The driver of

a vehicle approaching a YIELD sign shall slow to a speed of not more than ten miles per hour and yield right-of-way to all vehicles approaching from the right or left on the intersecting street which are so close as to constitute an immediate hazard (47h). "If a driver is involved in a collision at an intersection or interferes with the movement of other vehicles after driving past a YIELD sign, such collision or interference shall be deemed prima facie evidence of the driver's failure to yield right-of-way."

There has been no legal contesting of the YIELD sign; either to our right to set the sign, or for the police department to enforce it. To date, there has been no legal opposition to the YIELD sign in any way. There has been no public criticism of the sign or its installation.

Almost daily we get requests for additional installations. In fact, there are requests to substitute the YIELD sign for the majority of two-stop installations in residential areas, not involving through streets. The reason, which is obvious, is for their effectiveness and their lesser restrictiveness on the cautious and prudent driver.

'Slow' Panel

To the first several installations of the YIELD sign was added a separate panel bearing the word SLOW. This was added in the initial stage to aid in the transition and educational phase of the YIELD signs introduction on the streets of Tulsa. It was believed that if the driver did not understand the YIELD right-of-way message, he would at least be warned of a possible cross-street hazard with the SLOW panel, and in so heeding the slow sign would be protecting the priority street so designated by the YIELD sign installation.

Driver Observance

Five of Tulsa's twenty YIELD sign locations were selected for a detailed study of driver reaction. The locations were selected to represent five different and unrelated types of traffic. One is strictly residential with equal traffic on the two intersecting streets. Another is the intersection of a residential street with a volume of two to three hundred vehicles a day, and the other is a street with 600 to 800 ve-

hicles a day. The major flow is protected by the YIELD signs. A third location was selected because of the cross-street traffic and a surface drainage dip at each curb line of the intersecting street.

The fourth location was selected in a semi-industrial area adjacent to a shopping area. The sign is situated on the route taken by the driver-examiners when testing drivers for driver licenses. The fifth location observed is a marginal intersection to the downtown area. The YIELD sign was used to protect a wide minor street from a residential cross-street. The locations may not all meet the conditions for this type of control; however, they are all responding well to the YIELD sign treatment. They typify all of the experimental locations of the sign in Tulsa.

Field Observation

The locations were surveyed for one ten-hour day at three locations and for five hours each at the other two locations. Only daylight conditions were observed in this study. The weather in all cases was clear and mild. The study was made on average week days in September 1951.

Each intersection was observed as to the driver reaction to the YIELD sign, when approaching, observing and driving past the sign.

The speeds used as a guide to the observer were considered the speeds critical to this sign. Vehicles were checked as to their approach speed, their reaction to the sign and their continued activity across the intersection.

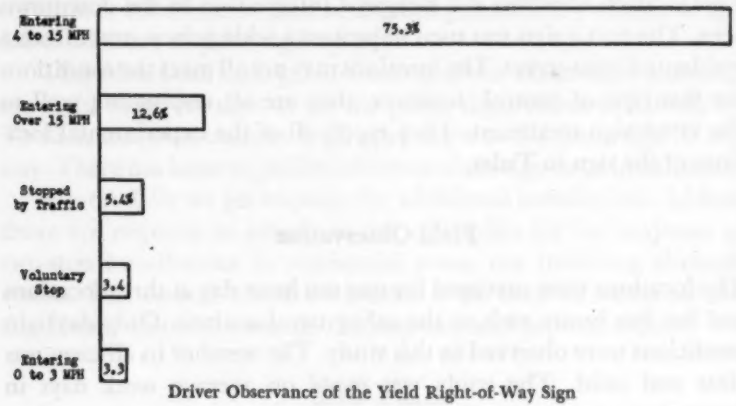
Though the ordinance, as stated before, requires that the speed be reduced to ten miles an hour, in the study we made, the braking point was set at fifteen miles an hour. This was done for two reasons. First, the speed through an open intersection in Tulsa is set by ordinance at fifteen miles an hour. Second, many drivers who do not choose to stop or turn will not reduce their speed to ten miles an hour.

Analysis of Data

All vehicles were classified, by the observer, in one of the five categories as follows: (1) entering fast—over 15 mph; (2) entering

slow—4 to 15 mph; (3) practically stopped—0 to 3 mph; (4) stopped by traffic; and (5) voluntary stop.

Figure 2 indicates the results of the study in which 2,235 vehicles were observed. Only 12.6 per cent of the entire group were considered in serious violation by entering the intersection and passing the sign at a speed greater than 15 miles an hour. It must also be



Driver Observance of the Yield Right-of-Way Sign

FIGURE 2

pointed out that of this 12.6 per cent, or 281 vehicles, 215 were observed at one location. This might well indicate that another type of traffic control would be more desirable at this location.

Seventy-five and three-tenths per cent entered the intersections within the safe speed range. They did not stop, but proceeded on through the intersection after observing the cross-street traffic. To this percentage can also be added the 3.3 per cent who entered at a speed of 0 to 3 miles an hour. This brings to a total 78.6 per cent of the vehicles who were not required to stop and who did not choose to stop prior to entering the intersection.

As is also indicated in Figure 2, only 8.8 per cent of all vehicles stopped before entering the intersection and driving past the YIELD sign. It is further observed that of this number, 3.4 per cent stopped voluntarily, while 5.4 per cent were forced to stop by the cross-traffic.

The first analysis that might be made is that 94.6 per cent were not required to stop by cross-traffic. This is the margin of drivers we favor when we allow them to drive past a sign without stopping. This is also the percentage we would be requiring to stop at these locations daily if a stop were used instead of a YIELD sign. As the volume on the cross-street increases, the number of stoppages for the cross-traffic must naturally increase. As the volumes on both streets increase, a more rigid type of control will be necessary.

As was previously stated, the majority of violations to our rule were observed at one location. An analysis was then made of the remaining four locations. In this group, 1,348 vehicles were observed. Of this number, 83.1 per cent, approached the sign, observed the cross-traffic and proceeded into the intersection without stopping. Only sixty-six vehicles or 4.8 per cent entered the intersection at a speed greater than fifteen miles an hour. The remaining 12.1 per cent either stopped by choice or were forced to stop.

The analysis of the 1,348 vehicles, eliminating the large number of violations at the one location, does seem to point toward the results we were hoping to obtain when the sign had its beginning in Tulsa.

Drivers, after seeing the YIELD sign for the first time, were asked their opinion and interpretation of the sign. Without exception, the interpretation was clear, there was no question as to their responsibility, and with but few exceptions, most drivers replied they were not required to stop unless cross-traffic required them to do so. The fact that the public so readily accepts and observes this type of control led us to extend our experimental locations, after the first few signs were installed on a trial basis.

The accident experience at the twenty experimental locations has been exceptional. Though the twenty locations have been installed in a progressive manner through the first ten months of this year, we have had signs in place for ten months. With all of these locations dotted over Tulsa, we have had only one reported accident at all of the locations. The driver stated she did not see the sign at all and was cited with a "Failure to Yield Right-of-Way" traffic summons.

Conclusions

It cannot be said without reservation that the answer to the open intersection has been found. It can be claimed, however, that a forward step has been taken in the solution of the unnecessary stops caused by the stop signs at so many minor intersections.

Though this study is not considered conclusive, it does point out that by far the larger number of vehicles entering many intersections have no reason to stop, if the entry is made in a careful and prudent manner. It pointed out that less than 10 per cent were required to stop by the cross-traffic. This indicates the merits and desirability of the YIELD sign when the advantage to the driver amounts to a ratio of approximately 9 to 1. In effect this type of traffic control requires a stop only when a stop is really necessary.

This investigation has been limited by time, manpower and finances. It is our desire to continue this study, comparing it with other types of traffic control. It is also anticipated that other traffic officials will give the YIELD sign a fair and careful trial in their area.

As we are all seeking the best in traffic control methods and devices it is hoped that this suggestion, experiment and report will stimulate further research along this line.

Sizes of State Highway Systems: How Big Should They Be?

ROY E. JORGENSEN

Mr. Jorgensen is the Engineering Counsel for the National Highway Users Conference Inc., with headquarters in the National Press Club Building, Washington, D. C. Previously Mr. Jorgensen had been Deputy Commissioner and Chief Engineer of the Connecticut State Highway Department. Prior to becoming Deputy Commissioner in 1947, he had been Director of Highway Planning for the State of Connecticut. From 1930 to 1942 he was a highway engineer for the United States Bureau of Public Roads.

"After much thought and consideration, not to say worry and mental effort, it is my opinion, all side issues being swept away, a man's lower limbs, in order to preserve harmony of proportion, should be at least long enough to reach from his body to the ground."

ABRAHAM LINCOLN

THE SAME Lincolnian logic might be applied in answering this question about the size of the state highway system. The state highway system should be big enough to reach the local road system. In general, that seems from comparisons of the current situation and the trend over the years to be about the only really consistent characteristic of state highway systems. They are big enough to reach the local road systems.

As of 1949, North Carolina had the biggest rural state system, 62,206 miles, followed by Virginia with 47,586 and Pennsylvania with 41,730 miles. At the other extreme, Rhode Island had a rural state highway system of only 791 miles; New Jersey, 1,774; Vermont, 1,834; and Massachusetts, 1,848.

More significant than the mileage in considering the size of state highway systems is the percentage the system represents of the total road mileage. North Carolina's state system includes practically all rural roads—98.2 per cent. Virginia is similarly situated with 96.9 per cent of the rural mileage in the state system. On the other hand, Rhode Island has about a third of its rural roads in the state system and New Jersey only 9.7 per cent. The extremes, percentage-wise,

are Delaware, with 100 per cent of its rural roads on the state system, and North Dakota, with only 5.8 per cent on the state system. Nationwide, 19.0 per cent of the rural road mileage was under state control.

The foregoing has dealt only with rural roads. The situation in urban areas is similar, in that there is tremendous variation from state to state, but, in general, the percentage of the mileage under state control is smaller in urban than in rural areas. No state, based on 1949 data, has more than 49.3 per cent of the mileage on the state system, this being the percentage in South Carolina. A number of the states have extremely small portions of the urban streets and highways on their systems. Nationwide, as of 1949, 10.3 per cent of the urban mileage is under state control.

The Trend in State System Size

The state highway systems not only show great variations from state to state now, but reflect marked changes, over the years, within individual states.

Delaware, for example, had 21.6 per cent of rural roads in the state system in 1930 as compared with 100 per cent in 1949. Similar comparisons are as follows:

	Percent Rural Roads on State System	
	1930	*1949*
California	8.6	13.2
Georgia	7.0	14.9
Maine	9.8	50.4
Missouri	7.6	16.3
North Carolina	16.2	98.2
Pennsylvania	14.9	47.5
South Carolina	10.4	41.3
Virginia	12.8	96.9
West Virginia	12.0	95.8

The above show sharp increases in all cases, but there were some states in which the state system remained fairly stable. For example:

	1930	1949
Arkansas	12.8	14.9
Idaho	11.5	13.2
Illinois	10.2	10.0
Iowa	7.4	8.7
Kansas	6.6	7.3
Kentucky	24.5	19.0
Michigan	10.0	9.0

The situation on the urban parts of the state systems generally shows the same trend toward increasing mileages with wide differences in the rate of increase.

Another noteworthy factor in the trend for both urban and rural mileages is that in some states there are sharp increases (and in some few cases decreases) in one year, but in other states the changes occur in smaller increments over a period of years.

Chart 1 shows the nationwide trend of mileage under state control with separate curves for rural and urban areas.

Chart 2 presents a distribution of states according to the percentage of rural road under state control for the years 1930 and 1949. The changes from 1930 to 1949 in the two extremes (0 to 9.9 and from 40 to 100) are very interesting. However, from the standpoint of our question "how big should a state highway system be" it appears the trend here, as in Chart 1, would indicate only—" bigger."

Chart 3, similar to Chart 2, covers the distribution of states according to the percentage of urban mileage under state control. Here, as in the case of rural mileage, we see the trend from 1935 to 1949 reflecting expanding state systems in urban areas.

A state highway system, we may assume, should include as a minimum the most important interstate and intercounty routes because these are the ones of state-wide interest. Because the concept of the Federal-aid primary system fits these minimum specifications it might well be considered to represent the lower limit on the size of a state highway system. That is, the state highway system would have to be big enough to include the Federal-aid primary system. How does this fit what we have?

Judging existing state systems against this Federal-aid criteria, it

is believed there is general conformance in rural areas. That is, Federal-aid routes in rural areas are parts of the existing state systems. However, in urban areas there is not consistent conformance. Some urban links of the Federal-aid system are not under the administrative control of the state. They are not on the state highway system.

There is an argument against inclusion of urban extensions of main rural routes on the state system. In large cities these extensions in most cases follow the principal arterial streets. And, these streets serve large volumes of purely local intra-urban area traffic in addition to the traffic entering from the rural state highway. A major route serving predominantly non-local traffic in a rural area becomes a facility whose predominant service is to local traffic as it follows the arterial street in the urban area. Presumably based on predominant use, the arterial street should remain under city jurisdiction rather than become a part of the state system.

Thus, you would justify the urban gaps that presently occur in some state systems. Countering this argument is the desirability of providing continuity of responsibility along routes which are state highways. Regardless of the fact that the local traffic may exceed in volume the non-local, there is an obligation on the part of the state to provide continuity of improvement and maintenance on roads of state-wide importance. The basic concept then of the Federal-aid primary system representing the minimum for a state highway system appears sound. It may be that the state would find it desirable in some cases to have agreements with the cities providing for maintenance, by the latter, of routes following streets within their limits. But, the state would have the full determination of markings and signs and for the level of maintenance to be provided.

In a classification study made in Illinois and reported by the Department of Public Works in March, 1951, the approach to establishment of a state system was made on the basis of a thorough investigation of the functional usage of highways. Highways connecting the important populated places and carrying traffic of all types and characteristics were determined to be general-purpose routes properly the responsibility of the state. It is noteworthy that, while the recommended state system deviates in some respects from the

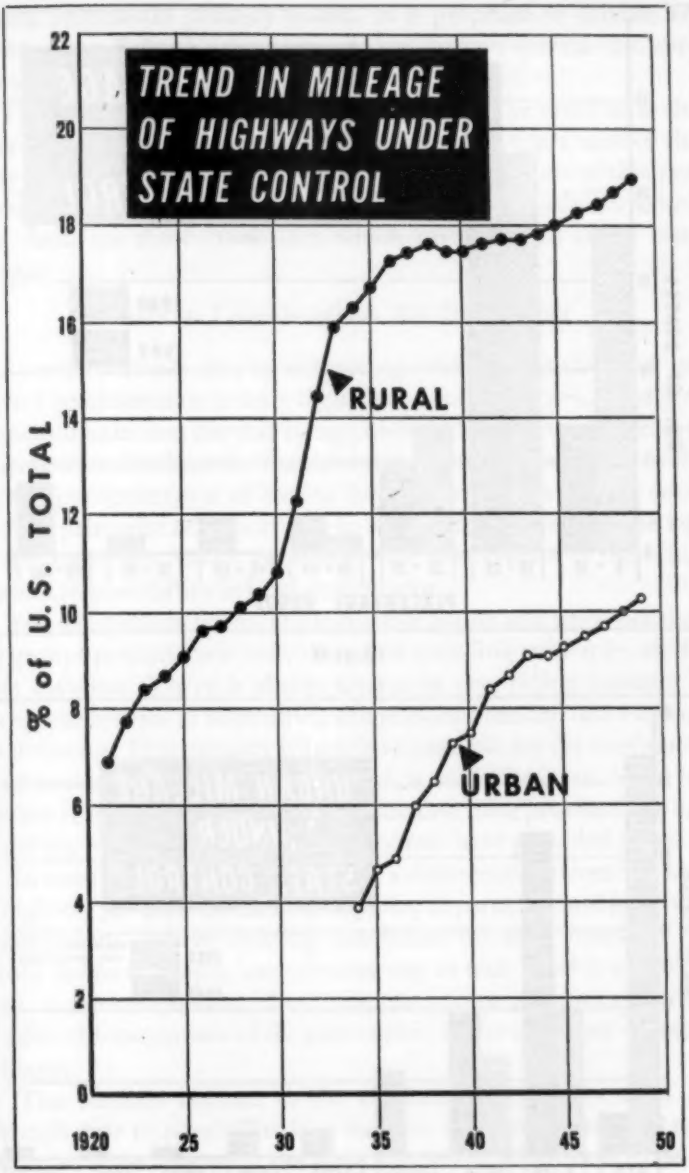

TREND IN MILEAGE OF HIGHWAYS UNDER STATE CONTROL
% of U.S. TOTAL
22
20
18
16
14
12
10
8
6
4
2
0
1920
25
30
35
40
45
50
RURAL
URBAN

CHART I

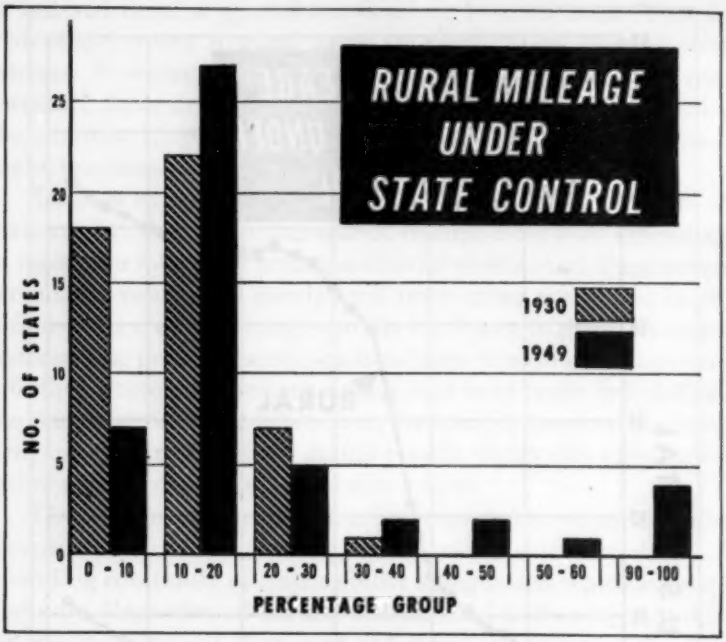


CHART II

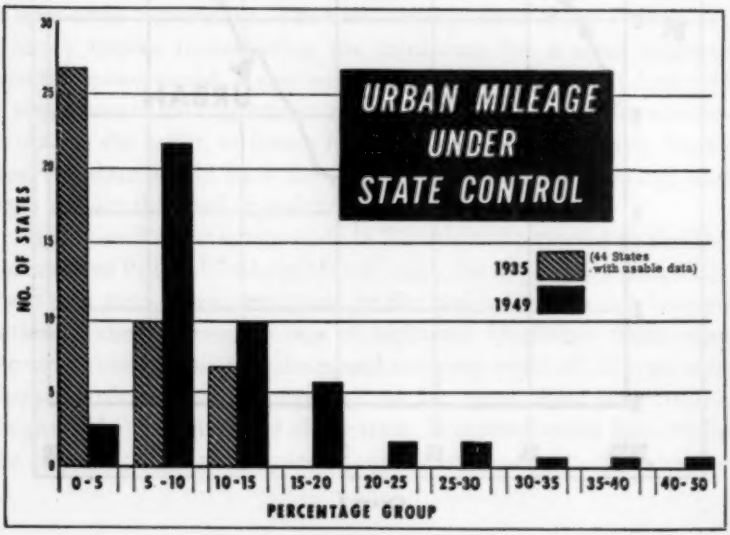


CHART III

present Federal-aid primary system, it is proposed to initiate revisions of the Federal-aid system to bring the two systems into conformance.

The Federal-aid primary system is sometimes referred to as the 7 per cent system, since basically it encompasses 7 per cent of the rural highway mileage, plus urban extensions. In view of this percentage, how can we account for the state systems greatly exceeding this? And, are there conditions which justify much larger state systems?

Financial Considerations Are Over-riding

It is understandable that in delimiting road systems the most important consideration to state legislature representatives, local governmental units and the taxpaying public is the anticipated effect of road classification from the financial standpoint. We can make much of the appropriateness of having local governments handle roads that are primarily of importance to local people. Stress can be laid on the democratic values associated with preservation of the initiative and responsibility in local government.

Yet, when action is taken by legislative bodies and when petitioning groups present their case, these fine-sounding principles are far from inviolate. There is almost always an over-riding pressure to change the systems in ways which will provide financial relief to local governments. This pressure is largely responsible for the continuous trend toward larger state systems. And, it no doubt is one of the important reasons why local sources of taxation have provided less and less of the highway costs while state sources have provided more.

In most states there is likely to be a difference between the kind of highway job done by the state highway department and local road organizations. Where existing conditions on local roads do not satisfy the local people, one obvious way to seek relief is to get the road on the state system. Here again the pressure is always tending to affect the magnitude of the state system in the same way—to make it bigger.

The obvious counter to the obtaining of a better road job through state responsibility is to improve the standard of local road administration. Probably the most important conclusion to be de-

veloped from the U. S. Bureau of Public Roads' January 1950 report, "The Local Rural Road Problem," is that more can be accomplished through improved administration than in any other way. It isn't primarily a case of money but rather of seeing that we have good engineering and administration.

Unfortunately, it is a difficult problem in many states to get wide support for improved local administration and adequate engineering. It is easier to get support for transfers of individual roads from local to state systems. And, every transfer in this direction reduces the magnitude of the local system. Gradually, these smaller local systems may be reflected in a less and less adequate local road job because the system becomes too small to justify a full scale road organization. Under these conditions there may come a time when it will be in the public interest for all rural roads to be taken into the state system. The real loss at this point, as I see it, is not the giving up of local responsibility for administration (which obviously was not properly valued or the situation wouldn't have developed), but the loss of financial support from other than road user sources. It is a principle of sound highway finance that other beneficiaries besides the road users should contribute toward highway costs. But, the trend to state control of rural roads is bound to be accompanied with a loss of financial support from non-highway user sources.

Grants-in-Aid May Expand State System

In some cases, states have provided that roads improved with grants-in-aid to local governments will be taken into the state system. Connecticut has had a state-aid program of this type for many years. Not only did it result in continuous additions to the state system, but many of the additions formed stub-end or disconnected sections of the state highway system.

A recent report of the Texas Highway Department indicates the state system in that state had almost doubled from the close of World War II to January 1, 1951, because of the additions resulting from the Federal-aid secondary program. Apparently, as sections of the system are improved they are taken over by the state highway department.

It is apparent that state-aid programs which provide for taking over roads as improved has a continuing, system-expanding influence.

Summary

The subject is significant, involving important questions of highway finance and administration. It isn't just a case of what makes a nice-looking network for a state highway system. It is a subject on which research and study would be helpful as guides to policy formulation.

In the absence of thoroughgoing research, I make observations rather than conclusions.

1. The state highway system should include the important interstate and intercounty routes, and urban connectors of these routes.

2. Expansion of state systems beyond the inclusion of routes of state-wide importance is motivated primarily by financial considerations but also by desire for a higher caliber job than is generally done by local governmental units.

3. If there is a continuing trend in a state toward a larger and larger state system, it may be that full-scale state responsibility for rural roads is desirable.

4. Ideally, in the interests of encouraging and supporting local government, it would be desirable to have the state system limited to approximately 10 per cent of the total road mileage with a positive deterrent to further expansion. Some matching basis for local road support with state funds might serve as a counter to pressures for expansion and at the same time assure continuation of local financial support.

The Mid-Manhattan Bus Terminal of New York's Port Authority

AUSTIN J. TOBIN

Mr. Tobin is Executive Director of the $500,000,000 Port of New York Authority. He rose in the bi-state agency from law clerk in the Law Department in 1928, to the position of Assistant General Counsel in 1935, and to the top staff job in 1942. Mr. Tobin first achieved a national reputation through his organization of the Conference on State Defense in 1938. He was later selected by the Attorneys-General of the States to lead the state and local forces in the Conference. He is a member of the American Bar Association and of the New York State Bar Association.

VEHICULAR traffic congestion arises when too many vehicles conflict with too little street capacity in any given area. This concept of traffic congestion suggests two general approaches to its cure: one is to enlarge the capacities of the city's streets; the other is to remove from city traffic over-sized vehicles, which contribute substantially to congestion. The Port Authority has attacked the problem from both approaches.

In following the first approach to the reduction of traffic congestion, the Port Authority has taken care to provide adequate street approaches to absorb and diffuse concentrations of bridge and tunnel traffic. For example, to collect and distribute George Washington Bridge traffic adequately to the east side of Manhattan and the Bronx, the 178th Street Tunnel was constructed under the streets of upper Manhattan. A parallel tunnel now under construction under 179th Street will double the capacity to carry George Washington Bridge traffic under the streets of Manhattan Island between the Bridge and the Harlem River Drive and the Cross-Bronx Expressway now under construction.

At the Lincoln Tunnel, the Port Authority has constructed extensive approaches on both the New Jersey and New York sides of the Hudson River. As part of the construction of the tunnel in

the 1930's the Port Authority built, at a cost of $13,000,000, an approach ramp and two-mile underpass through three New Jersey municipalities,to provide a direct connection with the arterial state highways.

The Port Authority is now providing a $3,700,000 connection between the New Jersey Turnpike and the underpass approach to the Lincoln Tunnel so that Turnpike motorists will have a direct and speedy link to mid-town Manhattan by way of the Lincoln Tunnel. On the New York side the Port Authority has already expended $16,000,000 on Manhattan plazas, an entirely new north-south avenue running between 34th and 42nd Streets, and a direct ramp connection to the Port Authority Bus Terminal.

In connection with its plans for a third tube of the Lincoln Tunnel, the Port Authority will widen the New Jersey plaza, ramp and a part of the underpass at a cost of more than $11,500,000. On the New York side new plaza extensions and additional connections have been planned at a cost of about $22,000,000. An underpass will be constructed extending from the new third tube at 38th Street to 30th Street. This sub-surface eight-block extension will underpass 37th, 36th, 35th, 34th and 33rd Streets, but will have connections to 31st and 30th Streets. In addition the Port Authority's improved street connection plan includes the widening of 30th Street, 36th Street, and 41st Street to provide additional access to 9th and 10th Avenues, the main arteries for carrying traffic south and north to connections with crosstown streets outside of the theater and garment center areas. The Port Authority will also provide a new off ramp from the West Side Highway at 30th Street to provide motorists with a direct access to the new underpass.

In a report to the New York City Board of Estimate, Acting Commissioner T. T. Wiley of the New York City Department of Traffic stated that the Lincoln Tunnel third tube would be a major traffic improvement of great value to New York City and recommended that the City approve the Port Authority's proposal to build this tube and its related street improvements. Quoting this report, Commissioner Wiley summarized as follows:

"1) The proposal of the Port of New York Authority to add a third tube to the Lincoln Tunnel will double the capacity of the

tunnel during peak hours in the direction of the peak movement.

"2) The increase in traffic volumes from New Jersey can be assimilated into the street system provided that West 41st Street is widened between Dyer Avenue and Tenth Avenue, that West 30th Street is widened between Ninth and Tenth Avenues, and provided that the new roadway from the Tunnel Plaza to West 30th Street is constructed, all in accordance with the basic proposal.

"3) The serious congestion that now exists on the streets and avenues delivering traffic to the tunnel in the evening rush period will be eliminated."

Altogther, there have been constructed about $108,000,000 worth of street connections, approaches and plaza areas to handle the collection and distribution of traffic moving through and across the Port Authority's six inter-state tunnels and bridges. All of these approach systems were paid for by the Port Authority.

The Port Authority has, however, effectively attacked the problem of reducing traffic congestion on city streets by way of the second approach, namely, by removing from the city streets substantial volumes of such oversized vehicles as buses, which when using narrow city streets, contribute to city traffic congestion out of all proportion to their numbers. This has been accomplished by the construction and operation of a union motor bus terminal for inter-state buses in midtown Manhattan, whose access to the Lincoln Tunnel is by direct ramps. The commuter buses using the terminal now do not have to use the city streets at all.

Before describing this consolidated terminal structure, it would be well first to review briefly the historic events that led to its adoption.

Growth of Bus Industry Made Terminal Necessary

With the opening to traffic of the Holland and Lincoln Tunnels and George Washington Bridge, spaced in the years between 1927 and 1937, supplemented by the construction of arterial connecting highways in New Jersey, there was a rapid development of bus transportation to serve large areas of metropolitan northern New Jersey and southern counties of New York State on the west side of the

Hudson River. This rapid expansion in trans-Hudson bus travel can best be visualized by the figures on trans-Hudson bus trips.

In 1925, some 71,000 buses crossed the Hudson River. By 1935 there were 1,018,000 trans-Hudson trips and by 1950 this volume had increased to 2,483,729. This increasing volume of buses, combined with the general growth in motor vehicle usage, contributed significantly to the acute congestion and long delays on mid-Manhattan streets. An orderly solution of the bus terminal problem was consequently imperative. Fruitless were efforts by private industry, the City of New York and the bus companies themselves to provide a union bus terminal west of Eighth Avenue, outside the area of greatest mid-Manhattan congestion. In 1944, Mayor La Guardia requested the Port Authority to solve the problem.

The necessary legislation was passed by the two States in 1946 and a bond issue was sold in July 1947 to provide initial funds for acquisition of property and construction of the terminal.

If most of the bus lines were to be attracted to a union bus terminal located *west* of Eighth Avenue, outside the exceptionally congested Times Square area, in accordance with municipal policy, it was necessary to define this policy and apply it without discrimination to all interstate bus lines.

In January 1947, the New York City Board of Estimate adopted a resolution declaring it to be the policy of the City of New York that no new bus terminals or expansion of existing bus terminals would be permitted in the exceptionally congested area *east* of Eighth Avenue.

In reliance on this declaration of City policy, the Port Authority agreed to go forward with its terminal project to be located just west of Eighth Avenue. The necessary legislation permitting its financing had been previously passed by the New York Legislature and signed by Governor Dewey in 1946. In the same year, concurrent legislation had also been passed by the New Jersey Legislature and signed by Governor Edge.

Before starting the demolition of the buildings on the site of the terminal, it was first necessary for the Port Authority to relocate 599 families who were then residing on the terminal site and the approach ramp between the Lincoln Tunnel and the terminal. The

housing shortage having been particularly acute for the low income groups who resided on the terminal site, and in order to minimize the hardships of those tenants, concurrent legislation was requested by the Port Authority and passed by the New York and New Jersey Legislature in 1948 authorizing the Port Authority to acquire housing facilities to relocate these tenants.

Under the permissive legislation, fourteen tenement buildings were acquired and rehabilitated at a cost of about $1,200,000 and the 599 tenants relocated. In accordance with the requirements of the statute, the Port Authority sold and disposed of the housing facilities it had acquired well in advance of the July 1, 1951 deadline. The net cost to the Port Authority of this necessary relocation of tenants was under $500,000, in connection with a project whose total cost was $24,000,000.

Largest Bus Terminal: 125,000 Bus Passengers Daily

In December 1950, the Bus Terminal was opened to operation. It offers the most modern and convenient bus terminal facilities to be found anywhere in the world to 125,000 passengers who move through it daily. Almost 60,000 bus commuters who travel between New York and New Jersey every weekday, and 5,000 long-distance bus travelers who come into or leave the New Jersey-New York Port District daily from all parts of the country, have acclaimed this facility a tremendous boon to intercity bus travel.

The Bus Terminal, located as it is on the entire block between Eighth and Ninth Avenues and 40th and 41st Streets, one block from Times Square, has already replaced most of the inadequate terminals scattered throughout the center of Manhattan which were formerly used by all interstate buses. All commuter buses between midtown Manhattan and areas in New Jersey like Bergen and Passaic Counties, and Rockland County in New York, where rail service to mid-Manhattan is inadequate, now use the Port Authority Bus Terminal. There is only one exception, a bus company whose long-term lease at another mid-Manhattan terminal has not yet permitted transfer to the Port Authority facility. In addition, thirteen long-

haul bus companies serving all parts of the United States, use the terminal. These long-haul carriers are handling a growing bus passenger volume which, on a typical summer Sunday, exceeded 20,000 persons.

Modern, Convenient Facilities for Terminal Users

The Port Authority Bus Terminal incorporates the most efficient and modern design and engineering principles. One of the outstanding features of the Port Authority Bus Terminal is the elevated ramp between the Lincoln Tunnel plazas and the Terminal. Thus, commuter buses from New Jersey move directly to the Bus Terminal without touching local Manhattan streets. Bus companies have reported travel time savings up to 30 minutes by the elimination of time formerly wasted in crawling through the streets to old, inadequate bus terminals in the Times Square area.

The roof of the Bus Terminal provides a public vehicular parking area. This parking space is also served by the ramps that connect directly with the Lincoln Tunnel as well as with the city streets. The roof parking is managed by one of the largest operators of parking lots in the country and provides a 450-car parking facility right in midtown Manhattan.

At the Eighth Avenue end of the Bus Terminal, a direct underground connection with the 42nd Street station of the Eighth Avenue (Independent) Subway line provides a quick, easy transfer to the New York City subway system in all types of weather. In addition, an underground passageway along 41st Street permits bus passengers to walk with all-weather protection to the Times Square station of the IRT and BMT divisions of the New York City Subway system and crosstown shuttle lines. In line with its policy of constantly improving its facilities, the Port Authority is providing a distinctive sign and lighting system along the passageway to guide pedestrians between the Port Authority Bus Terminal and the Times Square subway stations.

The Bus Terminal has thirty-one motor stairs to insure the rapid and orderly movement of passengers between various levels of the

terminal. These make possible the handling of the tremendous volume of over 15,000 bus passengers during morning and afternoon rush hours.

The terminal consists of four levels of operation, two of which are for bus traffic. The lowest level is for long-distance buses and the uppermost for suburban commuter buses. In addition, two levels of spacious and comfortable pedestrian concourses are provided between the lowest and uppermost levels. The main concourse is on the street level and the suburban concourse on the next level above. These intermediate levels include ticket offices, waiting rooms, baggage rooms, shops, stores and other services for the convenience of the bus passengers and the general public.

On the main concourse, an information booth and telephone information center are staffed by specially trained Port Authority personnel. The information booth is now being enlarged to provide space for eight information clerks to serve the public. This bus information service rendered on behalf of all the bus lines in the terminal, makes available to bus travelers, in person or by telephone, complete information on schedules, routes and fares. The thirty-one ticket windows on the main concourse facilitate the purchase of tickets for both commuter and long-distance bus travelers.

Forty-One Stores and Concessions

On the one hand, to meet the needs of bus passengers and other terminal users for shopping, dining, recreation and other services, and on the other hand to make the project as close to being self-sustaining out of revenues from tenant carriers and from concessionaires, the Port Authority's planning and designing of this terminal included large and convenient areas for the development of concessions. The fees received from these concessionaires will ultimately yield more than 50 per cent of the Bus Terminal revenues and thus help to make the project self-supporting.

In planning the development of these concession locations, the Port Authority gave careful attention to types of appropriate businesses and proper locations in the terminal. The Port Authority further required that each be of the type that best satisfies public

needs and that furnishes, however modestly priced, the highest grade merchandise and the finest service. More than 2,500 firms and individuals applied for space.

Selection of the tenant and concessionaires is based upon the nature of the applicant's business experience, his knowledge of operating practices, his financial stability and a desire to cooperate with the Port Authority in fulfilling the needs of the bus traveler and the public. Each lease is individually negotiated. In most cases, the leases are for a long term and are based upon a guaranteed minimum annual rent against a percentage of gross receipts. All stores have modern, attractive glass fronts, efficient illumination and are air-conditioned.

Forty-one stores and concessions are serving the needs of the terminal users. These businesses include, among others, one of the largest drug stores in the east, restaurants, snack bars, a huge food market, a florist, a ticket agency, music store, two candy shops, five newsstands, a book store, two bake shops and a beautifully appointed bowling center with thirty alleys.

Summary

Commuters and other bus travelers are being provided with a modern bus terminal and at the same time, stores convenient to work, to home and to transportation. The steadily increasing patronage attests to the skillful planning and provides revenues to the Port Authority to meet carrying charges on a much needed project that has given substantial relief to traffic in mid-Manhattan. It has already removed from the city streets, in the most congested area in Manhattan, some 400 buses in a morning rush hour and will remove more in the future.

Honolulu's Mauka Arterial

ROBERT M. BELT

Mr. Belt has been Superintendent of Public Works and Territorial Highway Engineer for the Territory of Hawaii since 1947. He has been with those departments continuously since 1931, except for five years of naval service in World War II. Mr. Belt is a member of the Honolulu Traffic Safety Commission and chairman of the Territorial Board of Harbor Commissioners. He is a member of the American Society of Civil Engineers, Vice President of the Hawaii section. He has written articles for Civil Engineering, American Highways, and other engineering publications.

TO UNDERSTAND Honolulu's traffic problems, it is necessary to know the factors it shares with all other American cities and the features unique to Honolulu.

Each of the Hawaiian Islands is of volcanic origin with more than half of the area in mountainous terrain, productive only insofar as it provides scenic beauty and valuable watershed area. All agriculture, commerce and general community life takes place on the sloping coastal plains between the foothills and the sea.

A common feature of Hawaiian highways is that the main arteries are the so-called "around-the-island" highways. Hawaii has no roads that stretch for mile upon mile through flat, open country. The heavily-populated southeast corner of Oahu is only ten miles deep from ocean to ocean.

Because of this generally circular pattern of highways, the conventional compass points in Hawaii mean little. As you drive around an island, the ocean may be to the east of you one hour, and to the west of you an hour later. For this reason, directions are given as "mauka" (toward the mountain) and "makai" (toward the sea), with well established points along the shore line, such as Diamond Head, used to identify the lateral directions.

Honolulu particularly hugs the sea. A quarter of a million persons, roughly half of the entire population of the Hawaiian Islands, live along the sea-coast between Pearl Harbor and the extinct Koko Head Crater. The 65,000 cars they drive, and the 30,000

cars driven by rural Oahu residents, must go to or through the city along a narrow strip of land one mile wide between Punchbowl Crater and Honolulu Harbor. The traffic flow map looks like the ribbon-bow on a gift-wrapped package, with the central business district representing the knot through which every traffic ribbon must be drawn.

Since 1938, the number of automobile trips made daily within Honolulu has doubled. Important streets are filled beyond practical capacity with the vehicles of commerce and pleasure—not for minutes but for hours each day. Finding a place to park and shop or do business has become a chore no one relishes. Retail business, sensitive to its customer demands, has decentralized at a thoroughly astonishing rate and in a completely indiscriminate fashion in its blind search for a solution to the traffic problem.

Honolulu's Arterial Plan

The business community, although originally unsympathetic to public off-street parking, has seen the light and is now aggressively supporting the City Planning Commission's off-street parking plan. Many businessmen are also beginning to recognize the possibilities and advantages of one-way traffic, although more education is needed in this direction.

Many people have speculated on the problem of how to deal with Honolulu's street deficiencies. Few people have dealt with facts. In 1940 the Territorial Highway Department conducted a simple origin-destination survey of vehicles entering and leaving the city and prepared a traffic flow map showing daily traffic density on the major streets. The 1940 data were studied by the City Planning Commission and were used to guide the preparation of a "major streets and arterials plan." This plan, which includes two east-west arterial highways, was adopted as a part of the Honolulu Master Plan.

Parallel studies by the Territorial Highway Department confirmed the need of two major east-west highways through the city. Mounting traffic statistics showed that the need was immediate.

With the inclusion of urban highways in the post-war federal-aid picture, the Territorial Highway Department saw the possibility of

doing something about it. Accordingly, a comprehensive Metropolitan Area Traffic Survey was undertaken in 1947 and 1948, under the supervision of F. H. Wynn, then director of the Hawaii Highway Planning Survey, and now with the Bureau of Highway Traffic at Yale University.

This survey was designed to explore all phases of traffic activity in Honolulu in order to show a more comprehensive picture of traffic conditions than had theretofore been available. Employing standard home-interview methods, together with special applications and techniques developed for this survey by the Bureau of Public Roads and the highway department, it was possible to prepare an accurate analysis of present and future traffic needs throughout the city.

The origin-destination survey was divided into three phases known as the "external study," the "home-interview" study, and the "truck and taxi" study.

The external survey was simplified because of Honolulu's ribbon-like development and ocean and mountain boundaries; there are only six highways leading into metropolitan Honolulu from rural Oahu. It was possible to station interviewers at these points of entrance and get a high percentage of interviews from those whose origin or destination was outside of the metropolitan area.

The home-interview study consisted of interviewing the residents of every tenth dwelling place, in their homes, to secure information about travel performed by each member of that household on a particular week day. Because of the heavy oriental population, it was necessary for many of the interviewers in certain sections to do double-duty as interpreters. University of Hawaii students, many with the required racial backgrounds and linguistic abilities, were used for this work.

Sanborn maps were used to obtain the 10 per cent sample on an absolutely impartial basis, and interviewees were notified well in advance, by letter addressed to street number only, that they would be interviewed. Even though advance letters carefully explained the reasons for the survey our office was flooded with inquiries as to "why are you going to build a road through our house?"

Truck and Taxi Study Interviews

The truck and taxi study was made by interviewing the drivers of every fifth vehicle, as obtained from registration files, to get a 20 per cent sample.

Interview data were checked by two sets of mechanical traffic counts—a "screen line" survey and a "control point" tabulation.

The two screen lines chosen were the Nuuanu stream, at the west boundary of the central business district, and the Palolo-Ala Wai Canals, between Waikiki and the east boundary of the central business district. Trips crossing the screen lines could be segregated without direct questioning, since trips from zones on one side of a screen line to zones on the other side could be determined from the origin and destination data.

For the control point check, control stations were located at Honolulu Stadium and Diamond Head Lighthouse. Space was provided on each interview form to show whether each trip had passed one or the other of these points. Interview figures were expanded to 100 per cent and checked against the mechanical counts at these stations.

The expanded trip data from all interviews were found to follow an hour-of-travel pattern closely resembling the ground count, although about 30 per cent of the ground count trips were not accounted for. Most important, however, was the fact that the "to work" traffic at the 7–8 a.m. peak hour was fully accounted for, indicating that the unreported trips were mostly of the non-work type. This experience has been encountered in other cities using the home-interview method, and probably indicates some reluctance on the part of many persons to discuss social and recreational traffic with the interviewers. Before the interview material was used for further analysis, non-work trips were expanded to account for 100 per cent of the screen line traffic.

Our survey showed that auto, truck, and taxi drivers performed an average of 284,169 daily trips in the metropolitan area in 1947. In addition, auto, truck, and taxi *passengers* performed 212,778 trips and *bus passengers* made 161,959 trips, for a grand total of 658,906

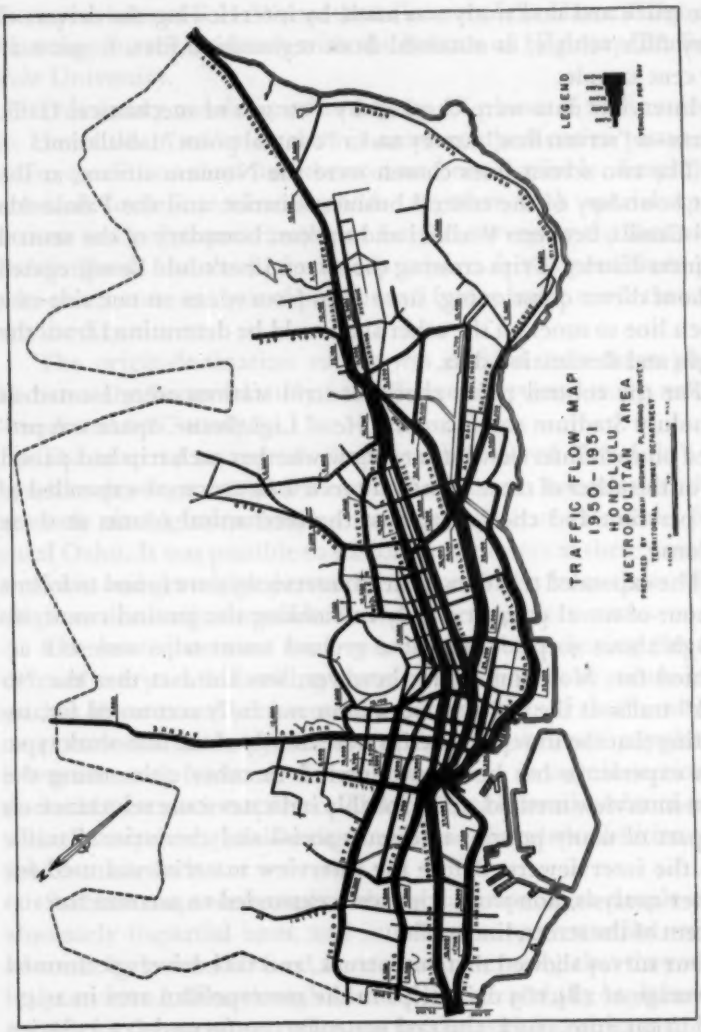
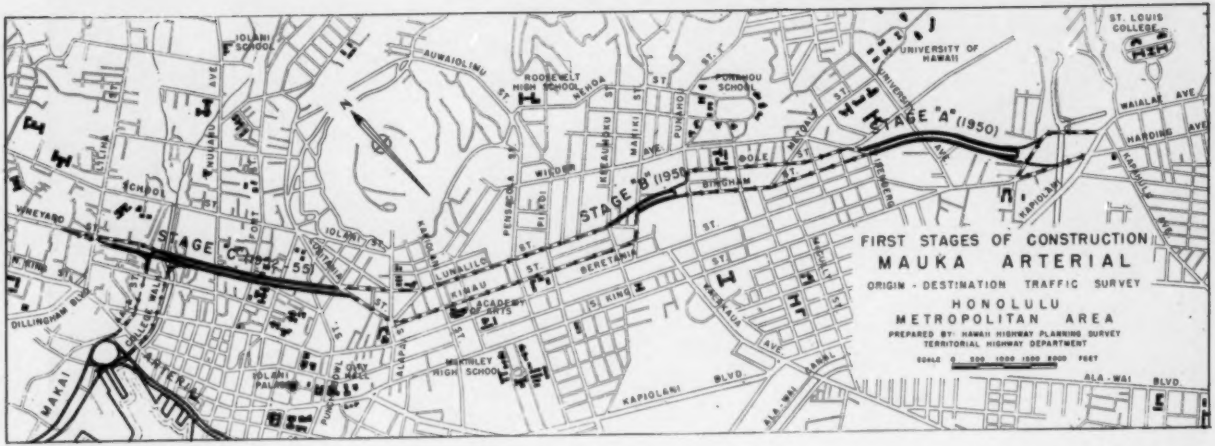

LEGEND
TRAFFIC FLOW MAP
1950-1951
HONOLULU
METROPOLITAN AREA

FIGURE 1

Here Is an Aerial View of Honolulu Harbor


FIRST STAGES OF CONSTRUCTION
MAUKA ARTERIAL
ORIGIN - DESTINATION TRAFFIC SURVEY
HONOLULU
METROPOLITAN AREA
PREPARED BY: HAWAII HIGHWAY PLANNING SURVEY
TERRITORIAL HIGHWAY DEPARTMENT
SCALE 0 500 1000 1500 2000 FEET
STAGE "A" (1950)
STAGE "B" (1955)
STAGE "C" (1952-55)
IOLANI SCHOOL
ROOSEVELT HIGH SCHOOL
PUNAHOU SCHOOL
UNIVERSITY OF HAWAII
ST. LOUIS COLLEGE
McKINLEY HIGH SCHOOL
KAPIOLANI BLVD
ALA-WAI BLVD
MAKAI ARTERIAL
DILLINGHAM BLVD
KING ST
BERETANIA ST
PIIKOI ST
PUNCHBOWL ST
ALAPAI ST
KEEAUMOKU ST
WAIALAE AVE
HARDING AVE
KAPAHULU AVE
KAPIOLANI BLVD

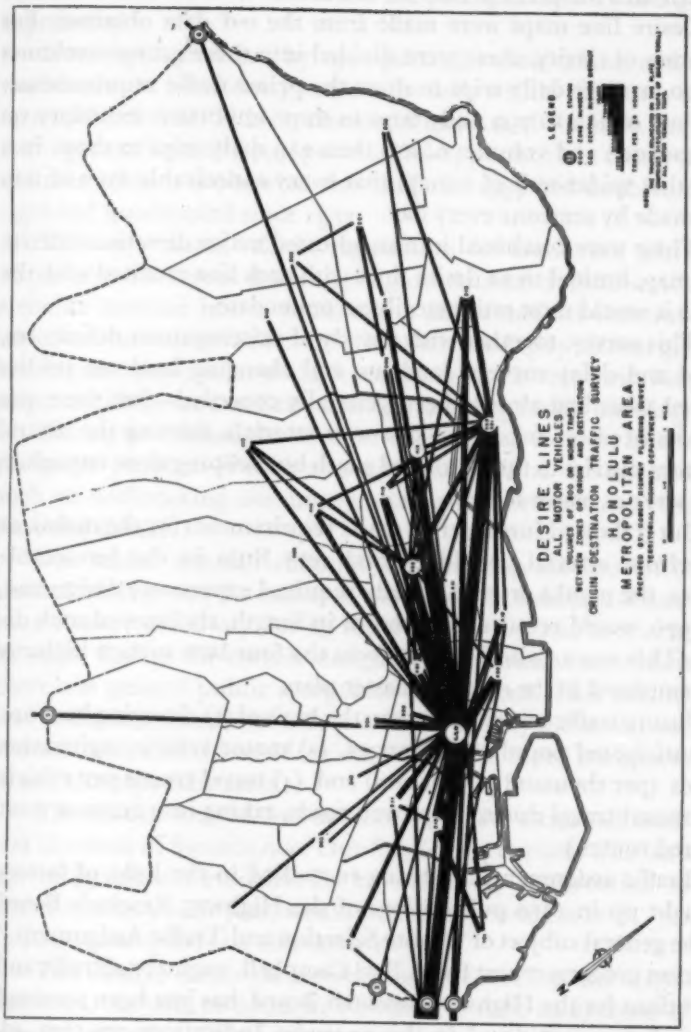

DESIRE LINES
ALL MOTOR VEHICLES
ORIGIN - DESTINATION TRAFFIC SURVEY
HONOLULU
METROPOLITAN AREA

FIGURE 2

daily trips—an average of nearly two trips each day in the metropolitan area for every person on the island!

Desire line maps were made from the o-d data obtained. For purposes of clarity, these were divided into three groups—volumes of 800 or more daily trips to show the prime traffic requirements; volumes of 250 to 799 daily trips to show important secondary requirements; and volumes of less than 249 daily trips to show, in a veritable spider-web of a map, that every conceivable type of trip was made by someone every day.

These were combined into an adjusted major directional desire line map, limited to 22 desire lines with each line credited with the traffic it would most satisfactorily accommodate.

This survey, together with a study of existing street deficiences, speed and delay surveys, land use and changing land use studies proved what had already been generally conceded—that there was definite need for two major east-west arterials, skirting the central business district to the north and south but keeping close enough to it to serve as major feeders.

But it showed further that, while requirements for the makai, or waterfront arterial, would expand very little in the foreseeable future, the mauka arterial already required expressway design and, by 1970, would require, for most of its length, six lanes of such design. This was a radical change from the four-lane surface highway contemplated in the original master plan.

Future traffic was estimated on the basis of (1) changing land use, (2) anticipated population changes, (3) motor vehicle registration trends (per thousand population) and (4) travel trends per vehicle (increased travel due to improved roads, taking into account most favored routes.)

Traffic assignments are being re-studied in the light of factors brought up in 1950 publications of the Highway Research Board on the general subject of "Route Selection and Traffic Assignment." A recent progress report by M. Earl Campbell, engineer of traffic and operations for the Highway Research Board, has just been received and is being considered in this re-study. Indications are that, although our original traffic assignments to the mauka arterial were

high, the 1970 traffic of the highway will average in excess of 60,000 vehicles a day, which is well above the practical capacity of a 4-lane expressway.

It was estimated that by 1970 passenger cars, trucks, and taxis would account for about 450,000 trips daily within the limits of the metropolitan area. This represents an increase of about 60 per cent over 1947 traffic in a 23-year period. This appears to be a conservative estimate when it is observed that traffic in 1947 had doubled since 1938 and quadrupled since 1932.

The 1950 motor vehicle registration for Oahu was 98,134, a 20 per cent increase over the 1948 figure. Annual traffic counts show a similar increase in two years, which might indicate that our estimate was too conservative. On the other hand, population growth leveled off sharply prior to the Korean war and is only now, with the impetus of increased military activity, showing a mild upswing.

Having established the need for the facilities, we were faced with the larger problem of their accomplishment. The five essentials in such an undertaking are money, public support, money, right-of-way, and money.

The makai arterial, although representing the less critically-needed facility, was the easiest of quick accomplishment. Parts of it were already underway during the traffic survey, and financing was in sight. Except for certain design features which were resolved, there was general public acceptance of the need. This was in part due to the fact that the land required was largely industrial and the industrialists affected could see the need of improved transportation to and through their areas.

The mauka arterial was another story. Its estimated total cost was in excess of $30,000,000. Our financing program, with an average of $5,000,000 available for new highway construction in the entire territory each year, would permit expenditure of $1,500,000 to $2,000,000 yearly on this facility.

The choice, then, was between bond financing and stage construction. As will be brought out later, public acceptance of the development had not, and in fact has not, reached the point where a bond issue could have received favorable legislative action. So,

with full knowledge of all of the disadvantages of stage construction, we settled on this method as the only one feasible under the circumstances.

The general east-west pattern of city streets made possible a program whereby, with the construction of two short sections of expressway, existing parallel streets now being used below practical capacity, could be converted to one-way use and bring quick relief to half of the total six-mile project.

With the beginning of surveys in 1949, the old hue and cry, familiar to everyone who has ever launched such a development, was started. A few astute politicians picked up the ball, if, indeed, they were not ones who had actually started its forward motion, and organized protest clubs, held public hearings, circulated petitions, and even threatened legal action.

Responsible organizations in the community, such as the City Planning Commission, the Traffic Safety Commission, the Engineering Association, and the Municipal Affairs Committee of the Chamber of Commerce, all supported the highway department—but in a dignified manner that rarely made the front page and was usually good for not more than two paragraphs on page 13 near the stock market quotations.

The resistance reached its peak in the 1949 session of the Territorial Legislature, with Honolulu legislators either opposed to the highway or hesitant about taking a position on it and outer island legislators personally disinterested but using their voting power as a strong trading measure. One measure, stipulating that no construction could be initiated without the prior consent of the affected property-owners, actually passed both houses of the legislature. This was properly vetoed by Governor Ingram M. Stainback on the ground that it violated the entire principle of eminent domain. The veto was sustained, but another bill, stipulating that no fuel tax revenues could be used for this construction, was passed in the last minute rush of the final day of the session. Again Governor Stainback saved the project—this time by a pocket veto.

Within a matter of days after the Governor's final action, an astounding thing happened. Property-owners along the route came to the office asking us to buy their property. These included two officers

of the association that had been organized to fight the project, as well as many property-owners from Bingham Tract—the very heart of the opposition territory. As of September 15, 1951, forty of the sixty-two parcels required in this tract had been acquired on the basis of the Territory's appraisals.

In other areas along the route, the same situation prevailed, and the Territory has now acquired, on a voluntary sale basis, more than $1,250,000 worth of land and improvements required for the expressway. Some of these areas will be needed this year; others not for several years.

The Territory has suddenly found itself in the property management business. Properties are being rented to the former tenants, if requested, or to others, with contracts stipulating that occupants will vacate on ninety days' notice. All rental rates are based on purchase price at rates of six per cent for income property, five per cent for straight residential rental property and four per cent for church property. All repairs are the responsibility of the tenant.

Since the Territory can borrow money at less than three per cent, this is good business as well as a necessary prerequisite to construction of the project.

Plans for the first unit, in the vicinity of University Avenue, have been completed and the project will be advertised as soon as all right-of-way is acquired and the tenants have moved. This is expected to be about the end of this year.

Plans for other units are being worked out with the City Planning Commission and will be placed under construction in accordance with our stage construction program. One deviation from the originally contemplated alignment has been found necessary due to plans of the Urban Redevelopment Commission for a major redevelopment project in the area adjacent to and north (mauka) of the central business district.

Agreement has been reached with the City Planning Commission to route the expressway around this area but to carry a four-lane divided arterial at grade between the redevelopment area and the central business district as a distributor for downtown traffic.

It is interesting to note that there have been two special sessions and one regular session of the Territorial legislature since the hectic

era of 1949, and the mauka arterial has not even been a subject of discussion.

This is the best indication of general public acceptance of the proposal. Another is the way in which people now speak of such a situation being improved *when* the mauka arterial is built. Two or three years ago they would not have used even the word "if."

There are still many individual problems to be solved and many individuals to convince. There are still one or two differences in opinion on design to be worked out with the City Planning Commission. Taking of church property presents a major problem, as it is much easier for an individual to find a new home than it is for a church to find a large enough site for relocation in the same neighborhood.

But the prognosis is good—if we live long enough.

Transit Traffic Engineering

BURTON H. SEXTON

Mr. Sexton has been Traffic Engineer for the Capital Transit Company of Washington, D. C. since May 28, 1951. He was the 1949–50 recipient of the American Transit Association's Gordon-Cass Memorial Fellowship in traffic engineering. He is a junior member of the Institute of Traffic Engineers; a member of the District of Columbia Commissioners Traffic Advisory Board, and a member of the District of Columbia Trucking Association. He was formerly the assistant director of research and schedules for the Indianapolis Railways, Inc.

IN LARGE cities, a majority of the population depends almost entirely on mass transit. The proportion that will use mass transit generally depends upon the following:

1. Whenever densely populated areas are within a reasonable commuting distance from the central business district, and

2. Whenever the lack of parking facilities, either curb or lot, restricts the use of the private automobile.

However, use of the private automobile continues to increase; and with that greater use has come more control of private motor vehicle movements. This greater control has increased, either directly or indirectly, the traffic interference with the movement of the mass transit vehicle. The transit vehicle is the most economical user of street space as far as passengers are concerned. This economical use should be carefully considered by transit and traffic authorities to reduce downtown congestion.

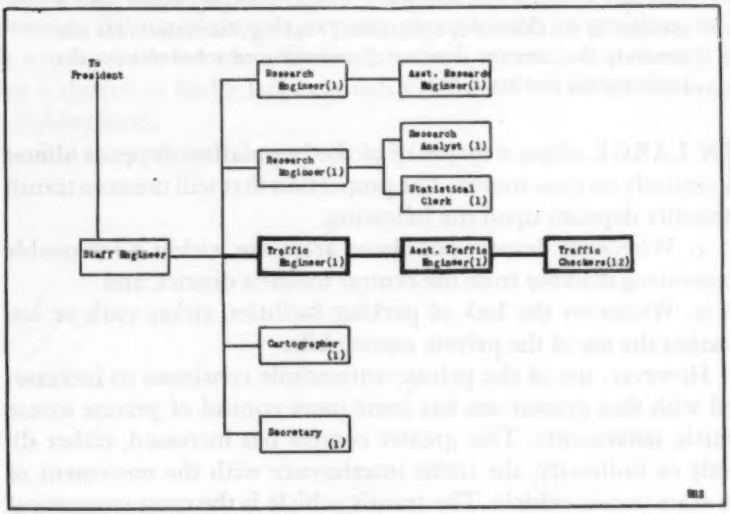
Some transit companies have neglected an extensive use of traffic engineering methods to cope with this congestion. The result of the neglect is obvious. The use of the city street by the transit vehicles and the importance of transit to the well-being of the community are frequently overlooked by the traffic authorities.

It is essential that urban transit management become adequately informed of the traffic engineering practices employed in their operating areas. It is important that transit companies employ proper traffic engineering techniques. By an audit of the city government's

methods of traffic control, and only by such an audit, can the transit company be assured it is receiving the needed proportion of street space and traffic control.

The Transit Traffic Engineering Staff

The size of the traffic engineering staff within an urban transit company depends upon the size of the operating property. It can be



Capital Transit Company Organization Chart
Research and Planning Department
August 6, 1951

FIGURE 1

understood that an operation rendering service to a city of 50,000 could not justify the services of a full-time traffic engineer. Yet the duties of the general manager of a small property or his assistant must include this responsibility. Regardless of the size of the transit company, someone should be assigned to the traffic engineering responsibilities.

An example of a traffic engineering staff within a large transit property is that of the Capital Transit Company in Washington,

D. C. This company has assigned personnel to traffic engineering responsibilities for several years. It has engaged a full-time traffic engineer since 1946. The traffic engineering staff within this company is an active unit of the Research and Planning Department. See Figure 1. The Traffic Engineer reports to the Staff Engineer, who in turn, reports directly to the President of the Company.

The Traffic Engineer has under his direction an Assistant Traffic Engineer and twelve part-time traffic checkers. The services of the other members of the Research and Planning Department are also available, as are the services of the sixty-three traffic checkers of the Schedule and Traffic Department.

The duties and responsibilities of the Traffic Engineer include the following:

1. The solution of general problems in traffic engineering relative to long range planning for transit routing, as well as those related to current adjustments which are designed to expedite transit service.

2. Studies of traffic signal locations and timing.

3. Fringe parking studies.

4. Comprehensive study of a city-wide traffic signal system, including the establishment of progressive timing for transit operations and the establishment of preferential streets for express and local transit service.

5. A study of the signing and marking of street car loading platforms.

6. Comprehensive study of the street pattern relating to the establishment of preferential and one-way streets and other methods of expediting all forms of traffic.

7. Studies of arterial street plans proposed by the various governmental and private agencies.

8. Studies of continuing major highway construction projects affecting transit operations.

9. Daily contacts and negotiations with the D. C. Department of Vehicles and Traffic and the Highway Department.

10. Representing the Company as a member of the D. C. Commissioners Traffic Advisory Board.

11. Representing the Company as a member of the Traffic Committee of the Washington Board of Trade.

12. Representing the Company as a member of the D. C. Trucking Association, and

13. Participation in the committee activities of the American Transit Association, Institute of Traffic Engineers and other trade and professional organizations.

With personnel informed of proper traffic engineering practices, every reasonable measure can be taken to expedite the movement of the transit vehicle. Corrective action toward minimizing traffic interference can be taken to meet the requirements of an efficient transit operation.

What Can Be Accomplished

Whenever congestion or traffic interference has been reduced, the efficiency of vehicular movement is generally increased. Congestion can be materially relieved through a wider use of transit. Since this remains more of an ideal rather than a practice, other corrective steps are necessary.

Corrective action to relieve traffic interference can be accomplished in various ways. The type of action is determined by establishing a priority of movement for either the private automobile or the transit vehicle. In some instances a priority of movement for one will not be detrimental to the movement of the other. The priority is in most instances based on the traffic volume. Whenever transit is included in a volume priority, the most important fact relative to the number of passengers carried is sorely neglected. Generally, whenever a movement priority is given to the transit vehicle, it will benefit the majority of the commuting population. The first step is to determine what type of vehicle should be attracted to use the street in question.

That consideration does not conclude that a street system designed to expedite transit vehicular movement will *exclude entirely* private automobile movement. It will, however, tend to *discourage* private motorists from using this street system.

Once the street has an established movement priority, that type of corrective action to expedite the vehicular movement can be applied.

Traffic Signals

The type of corrective action or the traffic engineering method that has gained wide prominence is the design of traffic signal systems. The design of a traffic signal system is based primarily upon the running time of the vehicles using the system. Because of the operating differences between transit vehicles and automobiles, a signal system designed for one in most instances will not be expeditious for the other. If the street is predominantly used by transit vehicles, the signal system should then be designed to expedite the transit vehicles' movement. Since a signal system of this type will be designed for lower operating speeds it will not be attractive to private motorists. The running time of a transit vehicle will include boarding and alighting. The traffic signal timing should be established to accommodate the maximum number of transit vehicles, so that boarding and alighting can be conducted primarily on the red indication and transit vehicles can resume the route on the green.

The timing of a progressive signal can greatly reduce the time a transit vehicle spends on a signalized street system. In some instances, because of the operating characteristics of the street, this can be accomplished without undue interference to the automobile movement.

In some cases the change from a single-phase operation to a multiphase operation can be detrimental to the transit movement. This is especially significant when street cars are considered. For example, the street car operating through a single-phase signal can usually push through without too much difficulty. Whereas, the street car operating through a multi-phase signal is usually restricted to permit the freewheel vehicular left turn. Or the street car is delayed when the through-movement is permitted by the back-up of automobiles on the car tracks awaiting the left turn indication. The question of the efficiency of the multi-phase operation when street cars or trolley coaches are involved is one of importance. Delays also occur between transit vehicles. If the left-turning vehicle is a street car or trolley coach, the other through-units must remain in line until the first has completed its turn.

One operational problem confronting transit management is

not only the increase in the number of multi-phase signal operations, but the lack of standardization of the signal indications. For the transit vehicle operator, it must be confusing to face a multiplicity of indications for like movements. The problem increases in complexity when the special indications are installed for the benefit of transit movements.

Favorable timing of traffic signals and hence the probable elimination of traffic interference increases the transit company's schedule efficiency. The increase in schedule efficiency will enhance the regularity of the transit service and should make it more attractive to the transit patron.

Parking

The efficient elimination or restriction of parking on congested streets or at points where the street design is not sufficient for expeditious movement helps both transit and automobile movement. The traffic lane acquired through parking elimination increases the active street capacity. The increase in usable operating lanes reduces traffic interference. This is of special importance during rush hour periods.

Most cities have passed through the era of overall or blanket parking restrictions. The passing of this era can probably be attributed to the development of the parking meter and the quest for additional revenues by the city governments. The parking meter should provide an adequate parking turnover. However, because of the police manpower shortage adequate supervision of the hour limitations, at both metered and signed areas, is often not enforced. In most instances the automobile remains at the curb as long as its owner deems necessary. Illegal street parking will continue to increase until limitations are enforced.

The result of the above is an increase in double parkers or potential parkers "cruising around the block" in an attempt to find curb space. Both of these factors combined with the increased parking lot charges, are creating additional traffic interference.

When a business district's streets become overburdened, a reevaluation of parking prohibitions is usually in order. To expedite

the vehicular traffic through the critical downtown areas there must be

1. Adequate prohibition and restriction of all curb parking, standing, double parking and curb turnover limitations, and
2. Sufficient enforcement of these parking regulations, especially during the critical rush hour periods.

Those steps will expedite the movement of all vehicles and will be of particular importance on city streets that contain a heavy transit movement.

The Prohibition of Turns

The prohibition of turns, and left turns in particular, will expedite the movement of all forms of traffic. There have been tremendous gains within the past few years in accomplishing the prohibition of turns at critical intersections. The problem that still exists is the mid-block left turns which are usually initiated from parking lots and garages, alleys or service entrances. The mid-block left turn can work havoc with a transit movement and its elimination is necessary for the efficient movement of all forms of traffic.

One-Way Streets

One-way streets cannot be utilized by transit operations as efficiently as they can be used to expedite the automobile movement. The one-way loop operation that is characteristic of a transit operation over a pair of one-way streets does have its disadvantages. If the transit operation is to remain an efficient one, it must be routed over the shortest route between the patron-demand areas and the business district. Probably the most important disadvantage to transit's use of one-way streets is exposing the transit patron to a longer ride. However, the advantages of a one-way street can also be applied to a transit operation. There will be an increase in the speed and the movement should become safer.

The use of one-way streets does involve the rerouting of transit vehicles. The proper routing of transit vehicles is extremely im-

portant to an efficient transit operation. The rerouting of transit vehicles will in many cases eliminate traffic interference. However, the rerouting of transit vehicles to expedite the automobile movement must not jeopardize the standards of efficient transit service.

From a traffic engineering standpoint the rerouting of transit vehicles in the congested business district will often be advantageous to both the transit and the automobile movement. The question of whether transit should be routed through the business district or looped to one side of this area requires considerable study and should not be settled in a haphazard manner. Not only is it important to consider the effects of a routing change upon all types of traffic movement, but any change of routing should be one that will attract transit patronage and not discourage it.

An evaluation of one-way streets to a transit operation may be summarized generally as follows:

1. One-way streets will expedite the movement of all types of vehicular traffic, but this does not mean that it will generally increase the efficiency of the transit operation.

2. One-way streets will attract the private motorists; this can be advantageous to transit if it diverts the automobile from using the streets that are predominantly transit, and

3. One-way streets will expedite the transit movement over existing one-way loops in the business district.

Lane Markings

One application of traffic engineering methods, one which is relatively simple but quite effective, is adequate pavement markings. Proper lane marking, with supervision of adherence to lanes, offers a remarkable relief from the confusion that is inherent in traffic congestion.

The lane markings that are continuous from cross-walk to cross-walk, will in most instances relieve traffic interference. Further relief is obtained from the designation of turning lanes.

Of particular importance is the use of lane markings at intersections that contain a street-car movement. This use is especially effective where there is a straight through-street car movement and a

heavy left turn automobile movement, provided that the adherence to lanes is properly supervised.

Express and Limited Bus Service

A method that can be initiated by the transit company for the benefit of the transit patron, as well as offering relief to traffic congestion, is the designation of certain rush-hour trips as express or limited stop service. The proper application of traffic engineering studies, mainly a passenger origin and destination study, will indicate the passenger warrants for this type of service.

In utilizing the express service to its full advantage, the elimination of boarding and alighting stops will reduce the transit running time and will relieve the traffic interference that can be created by these stops. The use of limited stop service is mainly for the convenience of the transit patrons that dwell in specific high density areas. This type of service allows only alighting movements along the main trunk until it reaches a designated downtown area.

Alternate and Skip Stops

The use of alternate and skip stops by the transit company can be utilized to minimize the transit vehicles' running time. As a general rule, whenever a transit vehicle does not have to merge in and out of a traffic stream to accommodate passengers at every designated stop, it will also relieve the general traffic of this merging interference.

However, it is important that the stops are not located in such a manner as to discourage patronage. Each transit route requires special study. Where the boarding and alighting movements justify the use of alternate or skip stops, and where the transit company is permitted to use them, they should be utilized.

Fringe Parking Lots

The acceptance of fringe parking by the private motorist has not been general. Probably the two major reasons for this are:

1. the additional restriction placed upon the use of the automobile, and
2. requiring the motorist to ride transit to and from the lot.

The use of traffic engineering methods in the development of fringe parking programs is important and should be given broad consideration. The probable reduction in traffic interference in the downtown area that could be achieved through the use of fringe parking lots is considerable. Probably of the utmost importance is the prohibition of all-day parking that would be imposed on the streets in a specified downtown area. This alone would offer the curb space to the short time parker, and bring relief to the double parking problem. Diverting the all-day street parker from the traffic movement in the downtown area should significantly reduce the peak-hour traffic volumes in that area. This fact would make full use of transit as an economical user of street space.

The movement of transit vehicles to and from the fringe parking lots would have to be sufficiently expeditious to attract the automobile commuter. Also of considerable importance to the automobile commuter is the combined cost of driving his vehicle to the lot, the parking charge, if any, and finally the transit fare. A transit fringe parking program will not only reduce traffic congestion and relieve many parking problems but will also emphasize the essentiality of transit.

The development of a fringe parking program by transit has not been from the standpoint of developing a panacea for all parking and congestion ills. It has been offered to the public authorities as one means of relieving the present traffic conditions. Transit recognizes the need, and by developing traffic plans of this nature hopes to stimulate interest and cooperation within other interested traffic groups toward a solution of the problem.

Transit Off-Street Terminals

Traffic engineering methods have been employed in the design of off-street transit terminals and loops in varying degrees.

In many cases where an increase in traffic volumes has created delays to the transit vehicles entering or leaving the terminal, special traffic signal installations have expedited these movements. The use

of a traffic actuated switch for street cars leaving the terminal or storage garage has proved effective. Where the traffic volumes are sufficient so that the run-on vehicles are delayed, the actuation interrupts the traffic stream only sufficiently to permit the transit vehicle to enter the street.

The installation of special signal heads at terminals for street car operation has also proved effective. In this case, the street car movement conforms with the directional automobile movement. A standard turn arrow indication is shown the street car operator when the movement is permitted. During the other phases of the signal operation the street car signal remains red.

Also important is the design or redesign of bus terminals to accommodate a larger sized vehicle. In the areas where the tendency is toward the adoption of the 102-inch wide and 40-foot long bus, considerable attention must be given to the terminal layout on the routes where the large bus will operate. The entire route must be investigated as to adequate street widths, curb radii and street characteristics necessary to accommodate the large vehicle.

Pedestrian Control at Intersections

The control of pedestrian movements at intersections is primarily concerned with two factors:

1. the safety of the pedestrian, and
2. the delays to vehicular traffic created by crossing pedestrians.

The installation of pedestrian walk-wait signals has assisted materially in the control of the pedestrian movement. The other important method of control is the restriction of turns. The turn restriction provides a safety measure for the pedestrian and eliminates the delay to all types of vehicles. This delay occurs when the turning vehicle is restricted from completing its turn until the pedestrian movement permits it.

Another effective method of providing for the control and safety of the pedestrian movement is the installation of safety islands. The above is especially true for a heavy pedestrian movement on a wide urban street. It is advantageous to both the safety of pedestrians and the reduction in traffic interference created by the pedestrian movement to have a safety island to split the pedestrian crossing in

half. It not only protects the pedestrian caught in the center of the street, but will also permit a more desirable signal timing. Street car loading platforms indirectly serve as pedestrian safety islands. The loading platform protects the adjacent crosswalk area and offers a pedestrian refuge from the freewheel movement.

Location of the Bus Stops

The proper location of bus stops is extremely important to the safety and efficiency of any traffic movement in congested areas. The old argument of the relative merits of the near side, far side or midblock bus stop is ever present. The conclusion that one is more advantageous than the other is erroneous when it is not based on an investigation of the facts. Each condition that exists for the individual stop must be studied. The type of bus stop to be used must be one that offers the least interference to the traffic movement, consistent with the safety and habits of the transit patrons.

The employment of traffic engineering methods relative to the type and location offers a sound engineering approach. General traffic considerations should be studied, such as the origin and destination of passengers. This study will include the transferring passenger and will determine the volume of transit passengers that will arrive and board at the location in question.

From this information can be determined what street crossing they require to complete their transfer or begin their ride. Also required are studies of traffic movements and volumes, together with the signal operation at the location. The street characteristics should be investigated, such as the width of the streets and sidewalks and the street grades.

The calculation of the length of the bus or trolley stop, once the location has been determined, offers an additional use of traffic engineering techniques. Important in this consideration are the characteristics of the transit vehicles that will be using the stop. The stop must be of sufficient length to allow the vehicle operator to pull in properly to the curb, so as not to obstruct freewheel vehicular movements on the street. The turning radii of the transit vehicle determines the length of the bus stop that is necessary for this turn-in movement. The length of curb space necessary for the turn-in move-

ment combined with the length of curb space that will accommodate the maximum number of transit vehicles using the stop at one time will determine the ultimate length of the transit curb stop.

In more recent street-widening programs, it was found advantageous to develop curb cut-backs for transit stops. This method releases all of the lane capacity for freewheel movement by providing the additional lane for the transit passenger stop.

Relative to the determination of the location and length of the transit stop is the effective signing and marking of the stop. Adequate pavement markings should identify the overall dimensions of the transit stop. Sufficient signs should be installed to identify the stop for the transit patron. Where there is a lack of pavement markings more attention should be given to the signing of the transit zone to offer additional identification for the private motorists.

Street Car Loading Platforms

Many cities have already converted from street car operations to bus and trolley operations and still more transit companies have included this conversion as a part of their long-range planning. Because of the above, the traffic engineering function of the location and design of street car loading platforms is decreasing. However, as long as street cars remain in operation the loading platforms are necessary.

The Manual of Uniform Traffic Control Devices contains detailed information relative to the warrants for loading platforms, their design and construction and the signs and marking that are necessary. Since the traffic engineering studies that are necessary for the location and design of loading platforms are similar to those required for transit curb zones, it is not deemed necessary to discuss it further in this section.

Cooperation with Traffic Officials

The full utilization and development of an efficient mass transit operation within a community should be incorporated in each municipality's long range plans.

The transit companies' efficient use of the street system and their

efforts toward the betterment of service should be kept fresh in the minds of the traffic authorities. Many are still inclined to minimize this efficiency. The transit company must have someone with traffic engineering training to whom the appropriate responsibilities are delegated. The traffic engineering representatives will generally be the contact with the municipal traffic authorities. There should be a high level of cooperation maintained between the city traffic engineering staff and the transit traffic engineering personnel.

To expedite transit service, the transit management must have traffic engineering know-how. The benefits will be twofold:

1. It will generally assist with the solution of company operational problems.

2. Through cooperation with the municipal traffic authorities, it will assist with the solution of mutual problems that will benefit both the freewheel movement and the transit movement.

The necessity for cooperation between the city traffic authorities and the transit company cannot be over-emphasized.

A Summary

The principal benefit of an application of traffic engineering methods to urban transit movements is operational economy. Minimizing traffic interference with transit vehicles will result in an increased schedule efficiency. The reduction in running time resulting over an accumulative period will be representative of a vehicle or unit savings. Consequently when the number of units are reduced, a savings is effected in manhours, both in operations and maintenance.

A benefit directly related to operational economy is a potential reduction in accidents. By applying sound traffic engineering practices to the traffic conditions of the various transit routes, the movement should become a safer one. The accident frequency is a chief factor considered in a transit traffic problem analysis. The elimination of potential or actual accident hazards is included whenever practicable in each traffic engineering recommendation.

The traffic engineer employed by an urban transit company can assist materially in maintaining efficient transit movements. He can,

by a comprehensive analysis of the following, attempt to keep pace with the control of the rapidly increasing vehicular traffic:

1. Traffic signal timing and progression for transit movement.
2. The elimination or restriction of parking, especially during rush hours in congested areas.
3. The warrants for street widening.
4. A study of preferential and one-way streets. Not only streets containing transit movement, but also opening other streets for vehicular movement, exercising care that no indirect hindrances will be exerted on transit movements.
5. The warrants for grade separations, both street and railway.
6. Adequate pavement lane markings and markings for loading platform approaches.
7. The warrants for skip or alternate stops.
8. Rerouting for a more expeditious movement, when such is in agreement with patron demand.
9. Encourage the enforcement of existing traffic regulations or the passage of new regulations by the authorities, whichever is required for expediting traffic movement.
10. Warrants for fringe parking lots and the effect of their operation on the central business district's traffic movements.
11. Proper design and construction of terminals and loops.
12. Design of loading platforms and the development of safe signing and marking thereof.
13. Pedestrian control at both intersections and loading platforms.
14. Restriction of turning movements at intersections, alleys or service entrances and at parking lots and garages.
15. Cooperation with traffic authorities to assist with the overall movement of vehicular traffic.

The above list of factors represents only the beginning of the transit traffic engineering job. Whenever possible, the importance of mass transit to the life of the community must be emphasized. If given assistance by the traffic authorities, mass transit can offer more expeditious service. When transit service can offer a time schedule competitive with the automobile, probable increase in transit patronage should assist materially in relieving congested arteries.

A Study of a School Crossing Hazard

ROBERT D. DIER

Mr. Dier is Traffic Engineer of Long Beach, California. When the study described here was made, he was Traffic Engineer of Fresno, California. He has worked in the highway and traffic engineering fields for twenty-three years. He is a member of the Institute of Traffic Engineers, and an Associate of the Highway Research Board.

A VEXING problem for state, county and city authorities is the school crossing hazard. Ever increasing volumes of vehicular traffic on streets and highways create both real and imaginary fears in the hearts of parents for the safety of their children at street crossings. Parents, individually and in organized pressure groups, harass public officials with demands for signs, traffic signals, adult guards, police guards, underpasses and what not.

In many communities, the feeling of parents has run so high that they have refused to permit the assignment of their children for duty on school safety patrols because they believed the conditions too hazardous. In a number of instances the existence of these worthy organizations has been endangered and sometimes their activities nullified because of fearful parents.

The responsibility of providing safety at school crossings usually ends on the shoulders of public officials. These representatives of the people, realizing that the public will hold them accountable should a child be killed or maimed at one of these pressure school crossings, often take what appears to be the easiest way out and bow to the demands of the pressure groups. Having once established a precedent for some type of safety installation, their troubles only commence as the demand for similar installations continue to roll in for hundreds of other school crossings.

Practical public officials must view this problem from various angles in order to arrive at a logical course of action. While they sympathize with parents' fear, they also know their responsibility to taxpayer and motorist to provide an efficient, economically con-

trolled street and highway system, free from unwarranted stop signs, traffic signals and other installations that may cause delay and congestion; or cause unnecessary expenditure of critically insufficient municipal funds. Public officials are torn between two apparent duties. Some decision is necessary.

Any final decision by public officials must be based on facts and not opinion. Parents will not be convinced there is no need for safety installations. Nor will the taxpayer and the motorist be convinced that the same installations are necessary if governmental action is based on opinion. In any controversy, one opinion is as valid as another. Only by obtaining facts and applying them logically can officials make convincing decisions.

Imperative needs are for a way to obtain pertinent facts of the problem, and for a formula to turn these facts into a practical solution of the school crossing hazard. It is true that a number of "rule of thumb" practices have been used to determine school crossing protection requirements, and possibly with satisfactory results. But there appears to have been no attack on the problem in which factors were considered which definitely effect school crossing safety. The theories and procedures to be discussed are based on every apparent factor influencing school crossing safety.

A safe condition at a school crossing might be defined in its simplest form as a condition in which an approaching vehicle is far enough from the pedestrian crosswalk to permit a child or group of children at the curb to analyze the hazard and walk across the street before the vehicle reaches them. The safe condition depends upon the time-velocity relationship between the pedestrian and the vehicle.

To determine the degree of safety at a school crosswalk a yardstick needs to be established to measure traffic conditions and analyze the hazard. The whole safety problem revolves around the actions of the pedestrians and the time taken to complete these actions. The safety yardstick will therefore depend upon the time it takes pedestrians to look both ways up and down a street, size up the hazard from approaching vehicles, and walk across the roadway. This time interval multiplied by the velocity of an approaching vehicle, in feet per second, would give the theoretical distance that vehicle should

be from the crosswalk to permit the pedestrian to make a safe crossing of the street.

With such a safety yardstick, the natural openings between vehicles within the traffic stream could be measured to determine whether children are being given sufficient opportunity to make a safe crossing of the street. Due to the fact that an extreme variation is found in vehicular velocities on a street, the problem of establishing a safety yardstick is not as simple as it appears. In order to take into account this variable factor of speed it becomes necessary to make certain assumptions to arrive at a single yardstick for measuring safety for pedestrian crossings.

The theoretical safety yardstick can not be based on the value of the highest vehicular velocity recorded on the street. To do so would set up a standard of safety that would classify certain school crossings as unsafe which actually could be considered safe. The standard of safety would be too high for practical purposes. In order to develop a more realistic and practical basis of comparison, it was assumed that as far as the higher velocities on the street are concerned, safety at the school crossing would have to depend upon the ability of speeding motorists to observe, react and brake their vehicles to a complete stop at the crosswalk after the entrance of the pedestrian into the crosswalk is first observed by the motorist. In this study it was assumed that the relatively few motorists who would fall within the upper twenty percentile of the vehicular velocity range determined for the street would be included in this category. The "minimum safe traffic gap or zone" later referred to in this article is based on this assumption and is defined as: the distance an approaching vehicle would have to be from the crosswalk to permit its operator to brake the vehicle to a complete stop at the crosswalk when traveling at the highest vehicular velocity commonly found and recorded on the street. No further consideration is given this 20 percentile group of motorists in the development of later theories and equations for the determination of school crossing safety.

As stated before, the "safety yardstick" or the "theoretical safe traffic gap" as it will be referred to from now on, is the distance an approaching vehicle would have to be from the crosswalk, and traveling *at a certain speed*, to permit a pedestrian to cross the street before

the vehicle arrived at the crosswalk. In this study it is assumed that this *certain speed* would be the 80 percentile velocity recorded on the street and which would take into account the 80 percent of the motorists not already considered in this safety study. It is also assumed that these motorists will not decelerate or brake their vehicles to slower velocities as they approach the pedestrian crosswalk.

The theoretical safe traffic gap which is to be the yardstick for the measurement of safety at the school crossing depends upon certain factors which definitely affect the safety of any pedestrian crossing. With these factors and the assumptions already made, it is now possible to arrive at an equation with which the theoretical traffic gap may be determined. Following is a discussion of the factors and a derivation of the equation:

Factor "W"—Critical Width of Pavement: The actual width of pavement in feet, in which pedestrians are vulnerable to passing traffic. These are determined as follows:

a. Distance between curbs where curb parking is prohibited.

b. Distance between parked vehicles where curb parking is permitted on each side of the street.

c. Distance between edges of pavement where earth shoulders exist.

d. Distance between a dividing center island on a divided highway and the curb or a parked vehicle on the opposite side of the roadway, depending upon whether curb parking is permitted.

Factor "F"—Additional Pedestrian Clearance Interval: The average time interval, in seconds, necessary to clear large groups of children from the critical width of pavement (W) and from the path of approaching vehicles. See Figure 2.

Factor Vp—Pedestrian Walking Velocity: The average walking speed of pedestrians or children, in feet per second.

Factor Vv—Vehicular Velocity: The 80 percentile velocity of vehicles as recorded on the street, in feet per second. The percentile velocity may be varied according to the desires of those making the study and in accordance with the degree of safety desired.

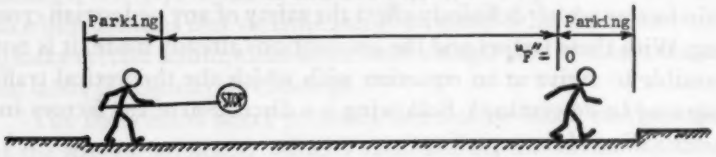
Factor P—Pedestrian Perception and Reaction Time: The average time interval in seconds required by a pedestrian, waiting at the

SCHOOL CROSSING HAZARD STUDY
CITY OF FRESNO, CALIFORNIA, 1951

DETERMINATION OF THE PEDESTRIAN VOLUME FACTOR "F"

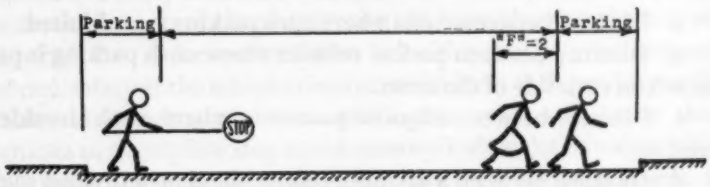
DEFINITION: Pedestrian factor "F" is the additional time in seconds necessary to clear multiple rows of children from the vulnerable pavement zone "W" when crossing the street at the same time. Each row is assumed to have 5 children in this study.

"W" = Critical Pavement Width



Factor "F" = 0 when 1 row of 1 to 5 children cross street at one time

"W" = Critical Pavement Width



Factor "F" = 2 seconds when a total of 6 to 10 children cross the street in two rows.

"W" = Critical Pavement Width

Factor "F" = 4 seconds when a total of 11 to 15 children cross the street in three rows.

$$\text{"F"} = \left(\frac{\text{Average Number of Children crossing each time}}{5} - 1 \right) 2$$

FIGURE 2

curb, to look in both directions along a street, analyze the hazard situation from approaching vehicles and commence the walking maneuver across the street.

Factor D_1—Theoretical Safe Traffic Gap: The theoretical safety yardstick representing the distance, in feet, an approaching vehicle would have to be from the crosswalk to permit a pedestrian or group of pedestrians to safely cross a street and taking into account the above factors.

Derivation of Equation No. 1 for the Theoretical Safe Traffic Gap

$\frac{W}{Vp}$ = Time in seconds required for a pedestrian to walk across the critical width of pavement W

T = Total time interval, in seconds, required for pedestrian to make a complete crossing maneuver across a street

$$T = \frac{W}{Vp} + F + P$$

$$D_1 = TVv$$

$$D_1 = \left(\frac{W}{Vp} + F + P\right)Vv$$

Vehicular traffic flowing across a school crossing restricts the chances of children to make a safe crossing maneuver by setting up a series of "gaps" and "crossing blockades" that alternately permit or block their movements across the street. The length and frequency of the traffic gaps, to a large extent, govern the safety at the crossing. If these traffic gaps can be measured in the field and compared with the Theoretical Safe Traffic Gap, the safety yardstick, the relative safety of that particular school crossing could be obtained.

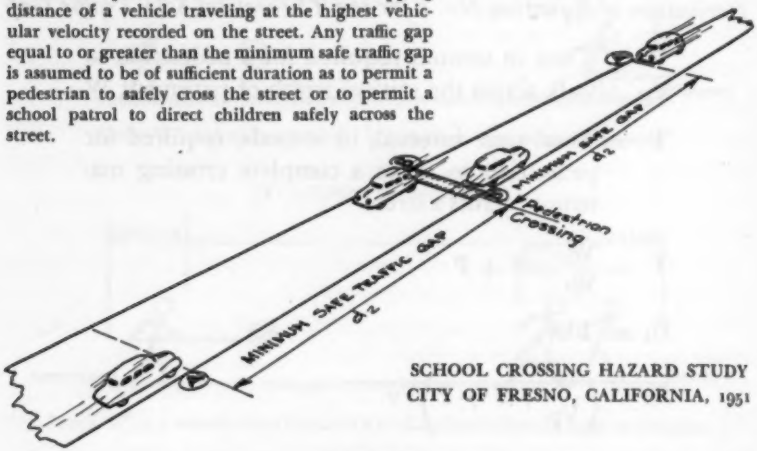
In this study it was found that through a technique of measuring the time interval of "crosswalk blockades" the average natural gaps in the traffic stream could be measured and compared with the Theoretical Safe Traffic Gap to determine school crossing safety.

In this research study, an unusual use has been made of the terms

"blockade" and "traffic gap" which is not familiar to the Traffic Engineering profession and requires definitions:

Crosswalk Blockade: The "crosswalk blockade" is determined by the length of the "minimum safe traffic gap" for each school crossing.

A pedestrian crossing blockade is assumed to be that period during which approaching vehicles are moving between points A and B and making it hazardous for a pedestrian to cross the street. Distance A to B represents the assumed minimum safe traffic gap which would permit a reasonably safe crossing maneuver for a pedestrian and is based on the stopping distance of a vehicle traveling at the highest vehicular velocity recorded on the street. Any traffic gap equal to or greater than the minimum safe traffic gap is assumed to be of sufficient duration as to permit a pedestrian to safely cross the street or to permit a school patrol to direct children safely across the street.



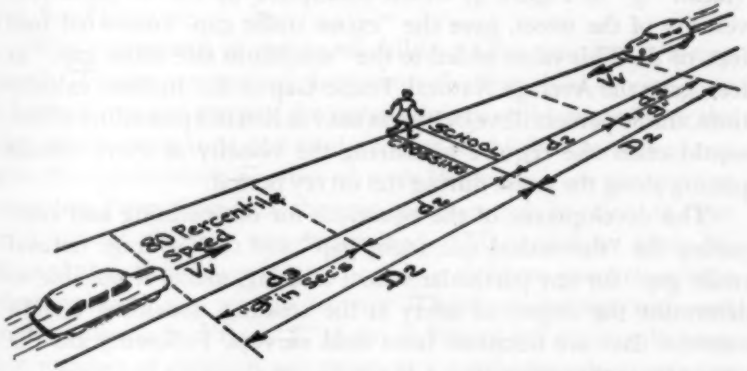
SCHOOL CROSSING HAZARD STUDY
CITY OF FRESNO, CALIFORNIA, 1951

FIGURE 1

As defined previously, it is equal to the stopping distance of a vehicle traveling at the highest recorded velocity on the street. This distance measured each way from the crosswalk establishes a "minimum safety zone" which determines the "crosswalk blockades." See Figure 1. A "crosswalk blockade" is said to exist the instant an approaching vehicle enters these minimum safety zones and continues to exist as long as any vehicle is approaching the crosswalk and is within these zones. A "crosswalk blockade" no longer exists the instant an approaching vehicle crosses the pedestrian crosswalk, *and, provided no other vehicles are approaching the crosswalk within the "minimum safety zones."*

Excess Traffic Gap: The termination of a "crossing blockade" interval immediately begins what will be called the "excess traffic gap." This latter time interval continues until the instant the next succeeding "crosswalk blockade" begins. In other words, the traffic flow is made up of alternating "blockades" and "excess traffic gaps." It can be seen in Figure 4 that the "excess traffic gap" is not the complete traffic gap available to pedestrians for a safe street crossing maneuver, but that there is an additional time interval available to

SCHOOL CROSSING HAZARD STUDY
CITY OF FRESNO, CALIFORNIA, 1951



EQUATION FOR AVERAGE NATURAL TRAFFIC GAP
as it exists at any pedestrian crosswalk

d_2 = Assumed minimum safe traffic gap *in feet*. Based on safe stopping distance of a vehicle traveling at the highest velocity recorded at pedestrian crossing. Takes into account driver perception time, reaction time and braking time.

"g" = Average gap in traffic in excess of the assumed minimum safe traffic gap as determined from field studies. Measured *in seconds*.

d_3 = Average gap in traffic in excess of the assumed minimum safe traffic gap. Value "g" multiplied by the 80 percentile speed of traffic in feet per second as measured at the crosswalk. Value *in feet*.

80 Percentile Speed = That speed under which 80 per cent of the motorists operate their vehicles along the street as measured with a stop watch over a measured course.

D_2 = Average natural gap in traffic *in feet* as derived from data obtained from field studies.

$D_2 = d_2 + d_3$

FIGURE 4

the pedestrian which is equal to the time necessary for a vehicle to travel through the distance represented by the "minimum safe zone." The complete natural traffic gap is the sum of these two time intervals.

Average Natural Traffic Gap: The "average natural traffic gap" is used as a basis of comparison with the "theoretical safe traffic gap" in determining the safety at school crossings. Due to the varying lengths of natural traffic gaps in traffic it was decided to use an average of the gaps as a basis of comparison. In this study, an average was taken of all "excess traffic gaps" recorded from field studies (factor "g" in Figure 4) which multiplied by the 80 percentile velocity of the street, gave the "excess traffic gap" converted into feet, or d_3. This value added to the "minimum safe traffic gap," in feet, gave the Average Natural Traffic Gap or D_2. In these calculations, the 80 percentile velocity was used in lieu of a procedure which would otherwise require measuring the velocity of every vehicle passing along the street during the survey period.

The development of the equations for determining and comparing the "theoretical safe traffic gap" and the "average natural traffic gap" for any particular school crossing, makes it possible to determine the degree of safety at the crossing, providing certain essential data are obtained from field surveys. Following are the types of surveys required:

1. Critical pavement width
2. Pedestrian walking velocity
3. Additional pedestrian clearance time
4. Vehicular velocity
5. Pedestrian perception and reaction time
6. Crosswalk blockade—Excess traffic gap.

As experience is gained in the use of this school crossing study technique, such unknown factors as, child walking speed, additional pedestrian clearance time, and pedestrian perception and reaction time, will eventually develop into constant values that should no longer require individual studies. The critical width pavement survey, the vehicular speed survey and the crosswalk blockade-ex-

cess traffic gap survey will always be necessary in any study of school crossing hazard. A number of the above mentioned field surveys are new to the Traffic Engineering profession and require further explanation:

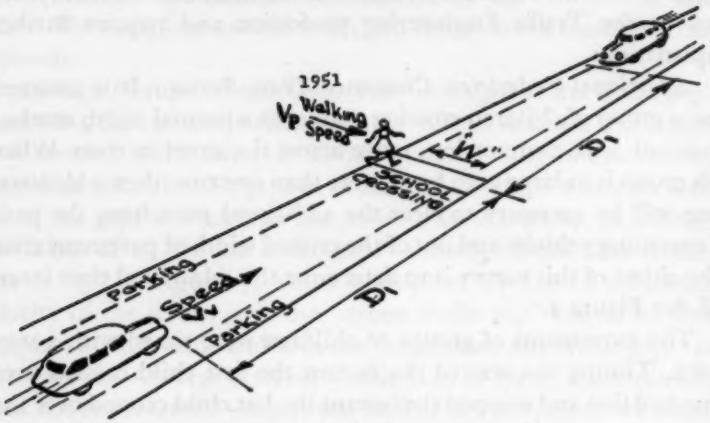
Additional Pedestrian Clearance Time Survey: It is assumed that a group of children crossing a street at a normal width marked crosswalk will, more or less, move across the street in rows. When this group is so large as to form more than one row, then additional time will be necessary to clear the additional rows from the path of oncoming vehicles and out of the critical width of pavement area. The object of this survey is to determine this additional time interval. See Figure 2.

The movements of groups of children were timed with a stop watch. Timing was started the instant the first child crossed over a marked line and stopped the instant the last child crossed over the line. At the same time, the total number of children in each group and the approximate number of rows formed in each group were recorded. From these data, the number of seconds required to clear each row of children was determined. This particular study indicated that there were approximately 5 children per row, with a clearance time of 2 seconds per row. These are the constants used in the equation for Factor "F" shown in Figure 3. Knowing the average number of children per group at a particular school crossing and substituting in this equation, Factor "F" can be obtained. The "mechanics" of the equation are:

1. The average number of children per group divided by 5 is equal to the number of rows.
2. The number of rows, less 1, is equal to the number of additional rows of children to be cleared.
3. The number of additional rows multiplied by 2 seconds is equal to the total additional pedestrian clearance time.

Pedestrian Perception and Reaction Time Study—This is a simple study by which the movements of the head of a person are timed with a stop watch. It was assumed that a child waiting at the curb for an

SCHOOL CROSSING HAZARD STUDY
CITY OF FRESNO, CALIFORNIA, 1951



THEORETICAL EQUATION FOR A SAFE TRAFFIC GAP
which permits a reasonably safe pedestrian crossing maneuver

W Critical width of pavement *in feet* in which a pedestrian would be vulnerable to moving vehicles or actual pavement width normally used by moving traffic.

F Pedestrian volume factor *in seconds.* Additional time required to clear larger groups of pedestrians out of critical width of pavement "W". See Figure 2.

V_p Walking speed of pedestrians *in feet per second.* Times of crossing of street based on width "W".

V_v Velocity of vehicle approaching crosswalk in *feet per second.*

P Perception and reaction time of pedestrian in seconds. Time necessary to look both ways along the street, size up the situation and begin walking movement across the street.

D_1 Distance *in feet* an approaching vehicle would have to be back from the crosswalk to permit a pedestrian to safely cross pavement through width "W".

DERIVATION:

$$\text{Time to cross street} = \frac{W}{V_p}$$

$$\text{Pedestrian perception and reaction time} = P$$

$$\text{Pedestrian volume factor} = F$$

$$\text{Total time for Pedestrian maneuver } T = \left(\frac{W}{V_p} + F + P\right)$$

$$D_1 = TV_v$$

$$D_1 = \left(\frac{W}{V_p} + F + P\right)V_v$$

FIGURE 3

opportunity to cross the street would be facing straight ahead, then would look each way to the right and to the left for approaching vehicles, then look ahead again and begin the crossing maneuver. This entire period of time has been called the pedestrian perception and reaction time. Its value was found to be approximately 3 seconds in this study.

Crosswalk Blockade—Excess Traffic Gap Survey: The purpose of this survey is to measure the alternating "blockades" and "gaps" in the traffic stream with a stop watch. Two survey personnel, a "timer" and an "observer-recorder" are required. "Minimum safety zones" are first measured each way from the pedestrian crosswalk, equal to the distance represented by the "minimum safe traffic gap" of that particular crossing.

The end of each zone may be marked with a small flag or may be the location of Enoscopes, to assist the "observer" in noting the instant an approaching vehicle enters the zones. The survey personnel station themselves at the school crosswalk. The "timer" starts the stop watch at zero and maintains a running time. As the observer calls out the instant vehicles enter the zones and leave the zones at the crosswalk, the "timer" calls out the elapsed time which is recorded on the form illustrated in Figure 5. The method of calculating the "crosswalk blockades" and the "excess traffic gaps" is also indicated on Figure 5. The average of all of the "excess gap" values obtained from these calculations gives the value of "g" in Equation No. 2 from which the Average Natural Traffic Gap is calculated.

The safety analysis of any school crossing is accomplished through applying survey data to Equations Numbers 1 and 2 which furnish values for the "theoretical safe traffic gap" (the safety yardstick) and the "average natural traffic gap" which represents the average opening in the traffic stream available to school children for a street crossing maneuver. A direct comparison of these two values on the following basis will classify the school crossing as to safety:

1. When the value of the "theoretical safe traffic gap" *is less than* the "average natural traffic gap" the school crossing is classified as *"safe."*

HAZARD SURVEY AT PEDESTRIAN CROSSWALKS INDICATING NATURAL GAPS IN TRAFFIC FOR THE CROSSING OF STREET BY PEDESTRIANS

LOCATION *East Tulare and First Street*

DATE *April 11, 1951*

RECORDING PERIOD FROM *2:15 P.M. to 5:30 P.M.*

(1) Gap or X-Walk Open Sec's.	(2) Time Car Entered Zone Min.	Sec.	(3) Time Zone Cleared Min.	Sec.	(4) X-Walk Blocked Sec's.
		0		10	10
6		16	1	03	47
9	1	12	1	24	12
4	1	28	1	52	24
22	2	14	2	18	4
8	2	26	3	03	37
17	3	20	3	31	11
3	3	34	4	01	27
5	4	06	4	19	13
2	4	21	5	06	45
7	5	13	5	18	5
4	5	22	5	55	33
5	6	00	6	04	4
3	6	07	6	11	4

EXPLANATION OF FORM USAGE:

Column 2—Time when vehicle enters the minimum safe zone.

Column 3—Time when the last vehicle creating a blockade crosses the pedestrian crosswalk leaving the zone open for pedestrian movement.

Column 1—Number of seconds of gap in traffic between successive blockades. Calculated by taking the difference between the time in Column 2 and that in Column 3 of the preceding line.

Column 4—Number of seconds of blockade at pedestrian crossing. Calculated by taking the difference between Column 3 and Column 2 of the same line.

FIGURE 5

DEPARTMENT OF PUBLIC WORKS
TRAFFIC ENGINEERING DIVISION

FIGURE 7

PRIORITY	LOCATION OF SCHOOL CROSSING	NAME OF SCHOOL	DATE OF SURVEY	TIME OF DAY OF SURVEY FROM	TO	CRITICAL STOPPING DISTANCE (d2) NO. OF FT.
1	Fresno at Lewis	Webster	2-13-51 1-26-51	8:25 A.M. 1:45 P.M.	11:00 A.M. 4:09 P.M.	220 220
2	Blackstone at McKenzie	Lowell	2-7-51 1-18-51	8:25 A.M. 1:40 P.M.	11:05 A.M. 4:35 P.M.	220 220
3	Fresno at Illinois	Jefferson	2-9-51 1-22-51	8:10 A.M. 1:40 P.M.	11:00 A.M. 4:35 P.M.	220 220
4	Wishon at Floradora	St. Therese	5-15-51 3-12-51	8:00 A.M. 3:00 P.M.	10:30 A.M. 5:00 P.M.	220 220
5	Blackstone at Princeton	Lafayette	2-7-51 1-18-51	8:25 A.M. 1:40 P.M.	11:05 A.M. 4:35 P.M.	220 220
6	Divisadero at Mariposa	Jefferson	2-16-51 1-25-51	8:20 A.M. 1:55 P.M.	11:10 A.M. 4:40 P.M.	220 220
7	Fresno at Floradora	San Joaquin Memorial	7-6-51 7-17-51	8:30 A.M. 1:30 P.M.	10:30 A.M. 4:30 P.M.	220 220
8	Moroa at Weldon	College Elementary	4-24-51 2-9-51	8:30 A.M. 1:30 P.M.	11:00 A.M. 4:25 P.M.	220 220
9	Van Ness at McKinley	Heaton	4-30-51 2-2-51	8:00 A.M. 2:00 P.M.	10:30 A.M. 4:30 P.M.	220 220
10	Tulare at Eighth	Jackson	2-2-51 1-16-51	8:25 A.M. 1:50 P.M.	10:58 A.M. 4:30 P.M.	220 220
11	C Street at Ventura	Lincoln	4-12-51 2-16-51	8:15 A.M. 1:43 P.M.	10:50 A.M. 4:30 P.M.	220 220
12	Wishon at McKinley	Heaton	2-6-51 2-6-51	8:25 A.M. 1:28 P.M.	11:00 A.M. 4:28 P.M.	220 220
13	Divisadero at Poplar	Lowell	3-23-51 2-14-51	8:30 A.M. 1:30 P.M.	11:00 A.M. 4:18 P.M.	220 220
14	Butler at Orange	Winchell	2-14-51 1-10-51	8:14 A.M. 1:41 P.M.	11:09 A.M. 4:14 P.M.	220 220
15	Belmont at Millbrook	Rowell	4-26-51 1-31-51	8:30 A.M. 1:55 P.M.	11:00 A.M. 4:30 P.M.	220 220
16	Fresno at Martin	Franklin	3-22-51 2-20-51	8:30 A.M. 1:45 P.M.	11:00 A.M. 5:30 P.M.	220 220
17	Palm at Dudley	Muir	4-17-51 2-5-51	8:30 A.M. 1:35 P.M.	11:00 A.M. 4:35 P.M.	220 220
18	Tulare at Sierra	Burroughs	5-3-51 2-8-51	8:00 A.M. 2:25 P.M.	10:30 A.M. 4:30 P.M.	220 220
19	California at Martin	Franklin	5-8-51 2-21-51	8:00 A.M. 1:25 P.M.	10:30 A.M. 4:45 P.M.	220 220
20	Maple at Illinois	Burroughs	5-10-51 3-2-51	8:00 A.M. 1:30 P.M.	10:38 A.M. 4:30 P.M.	220 220
21	Moroa at McKinley	Heaton	3-23-51	2:30 P.M.	4:00 P.M.	220
22	Kearney Blvd. and Trinity	St. Alphonsus	7-17-51 5-23-51	8:30 A.M. 3:00 P.M.	10:00 A.M. 5:00 P.M.	220 220

SCHOOL CROSSING HAZARD STUD

CITY OF FRESNO, CALIFORNIA, 1951

NUMBER OF CHILDREN CROSSING	AVERAGE NUMBER CHILDREN CROSSING AT A TIME	VEHICLES PER SURVEY HOUR	CRITICAL PEDESTRIAN WALKING DISTANCE (W)	NUMBER OF OPERATING TRAFFIC LANES	TRAFFIC SPEED HIGH MPH	TRAFFIC SPEED LOW MPH	80% SPEEDS MPH	80% SPEEDS FPS (Vv)	LONGEST IN SECONDS	SH SE
92	4	638	36	4	55	20	33	48	37	
77	6	873	36	4	44	17	33	48	38	
18	2	982	38	4	46	19	32	47	39	
31	3	1,033	38	4	50	12	34	50	29	
89	4	963	34	2	50	17	34	50	83	
75	6	989	34	2	47	15	32	47	25	
41	4	604	36	4	50	18	31	45	62	
48	4	472	36	4	39	19	31	45	36	
184	6	677	30	2	50	18	30	44	44	
264	7	856	30	2	50	10	30	44	29	
49	3	591	46	4	56	19	36	53	56	
63	4	663	46	4	40	12	30	44	55	
150	5	522	24	2	47	19	31	45	48	
150	5	569	24	2	47	19	31	45	57	
91	3	473	30	2	37	17	30	44	109	
93	3	498	30	2	39	15	29	43	57	
137	3	731	28	2	50	19	33	48	49	
45	2	760	28	2	42	15	30	44	41	
107	4	481	30	2	50	21	36	53	53	
126	4	473	30	2	47	18	30	44	44	
94	4	345	34	2	44	15	33	48	48	
110	4	495	34	2	47	17	31	45	106	
26	2	670	36	4	50	19	35	52	63	
57	2	500	36	4	47	15	35	52	44	
50	3	900	22	2	50	17	31	45	35	
53	3	726	22	2	39	15	30	44	41	
55	5	422	34	2	41	17	33	48	60	
101	4	363	34	2	50	10	32	47	41	
31	3	650	24	2	50	21	34	50	65	
34	2	745	24	2	50	17	31	45	41	
60	4	257	46	4	50	20	36	53	113	
64	4	210	46	4	47	17	33	48	59	
80	5	567	24	2	50	19	36	53	95	
62	2	499	24	2	47	13	37	55	57	
150	5	483	28	2	50	21	36	53	124	
184	3	611	28	2	50	19	35	52	51	
231	7	243	28	2	50	16	34	50	142	
250	6	298	28	2	50	10	29	43	61	
55	4	144	23	2	44	20	33	48	131	
39	2	125	23	2	41	17	31	45	60	
5	1	152	20	2	37	15	30	44	117	
220	5	91	28	2	50	20	36	53	164	
220	5	107	28	2	50	20	36	53	63	

D STUDY

1951

GAP IN EXCESS OF MINIMUM GAP					CROSSWALK BL		
ONGEST IN ECONDS	SHORTEST IN SECONDS	AVERAGE EXCESS GAP IN SECONDS ("g")	AVERAGE EXCESS GAP IN FEET (d_3)	% OF TIME OPEN	LONGEST IN SECONDS	SHORTEST IN SECONDS	A S
37	2	9	432	32	99	4	
38	2	8	384	26	86	3	
39	2	9	423	33	61	3	
29	2	7	350	21	115	3	
83	2	10	500	32	69	4	
25	1	7	329	25	121	3	
62	2	10	450	52	29	3	
36	2	8	360	33	57	3	
44	2	11	484	37	73	3	
29	2	8	352	26	128	4	
56	3	12	636	48	54	4	
55	2	12	528	39	60	4	
48	2	10	450	46	51	3	
57	2	9	405	46	37	3	
109	3	8	352	43	150	4	
57	2	11	473	39	56	4	
49	1	9	432	43	51	4	
41	3	9	396	33	63	3	
53	2	10	530	44	48	3	
44	2	9	396	35	66	3	
48	2	15	720	50	54	4	
106	1	11	495	46	48	4	
63	2	14	728	51	67	4	
44	3	12	624	44	49	3	
35	2	11	495	39	114	4	
41	1	10	440	35	95	4	
60	3	19	912	70	53	4	
41	2	12	564	45	54	3	
65	2	13	650	41	122	4	
41	2	10	450	38	55	4	
113	2	21	1,113	68	33	4	
59	2	16	768	59	66	3	
95	2	17	901	56	79	4	
57	3	13	715	51	58	3	
124	2	22	1,166	59	68	4	
51	3	13	676	51	43	3	
142	2	31	1,550	69	42	4	
61	3	16	688	53	54	4	
131	2	29	1,392	69	47	4	
60	2	17	765	66	36	4	
117	2	30	1,320	76	36	4	
164	2	32	1,696	83	23	3	
63	2	33	1,749	82	22	4	

LEGEND ($D_2 - D_1$) Column

(−) Designates theoretical deficiency in average natural traffic gap.

(+) Designates natural traffic gap in excess of the theoretical safe traffic gap.

OCKADE VERAGE IN ECONDS	% OF TIME BLOCKED	D_1 THEORETICAL GAP $\left(\frac{W}{3.5} + f + 3\right) Vv$ Feet	D_2 NATURAL GAP $(d_2 + d_3)$ Feet	$D_2 - D_1$ Feet	EVALUATION AS TO SAFETY
19	68	672	652	− 20	Unsafe
23	74	768	604	−164	Unsafe
19	67	658	643	− 15	Unsafe
24	79	700	570	−130	Unsafe
20	68	650	720	+ 70	Safe
21	75	705	549	−156	Unsafe
9	48	630	670	+ 40	Safe
16	67	630	580	− 50	Unsafe
18	63	616	704	+ 88	Safe
23	74	616	572	− 44	Unsafe
14	52	848	856	+ 8	Safe
19	61	704	748	+ 44	Safe
11	54	540	670	+130	Safe
11	54	540	625	+ 85	Safe
11	57	528	572	+ 44	Safe
17	61	516	693	+177	Safe
12	57	528	652	+124	Safe
19	67	484	616	+132	Safe
13	56	636	750	+114	Safe
16	65	528	616	+ 88	Safe
15	50	624	940	+316	Safe
13	54	585	715	+130	Safe
13	49	611	948	+337	Safe
15	56	728	844	+116	Safe
16	61	450	715	+265	Safe
19	65	440	660	+220	Safe
8	30	720	1,132	+412	Safe
15	55	624	784	+160	Safe
19	59	500	870	+370	Safe
17	62	450	670	+220	Safe
10	32	848	1,333	+485	Safe
11	41	768	988	+220	Safe
13	44	636	1,121	+485	Safe
13	49	550	935	+385	Safe
15	41	689	1,386	+697	Safe
13	49	572	896	+324	Safe
14	31	650	1,770	+1,120	Safe
14	47	559	908	+349	Safe
13	31	480	1,612	+1,132	Safe
9	34	450	985	+535	Safe
9	24	383	1,540	+1,157	Safe
7	17	689	1,910	+1,221	Safe
7	18	689	1,969	+1,280	Safe

FIGURE 6

2. When the value of the "theoretical safe traffic gap" *is greater than* the "average natural traffic gap" the school crossing is classified as being *"unsafe."*

The general theories and procedures advanced in this report resulted from a comprehensive survey and study of hazard conditions at twenty-two school crossings in the City of Fresno, California. A list of these crossings had been submitted to the City Commission of Fresno by school authorities with recommendations that 4-way stop, traffic signal and adult guard protection be provided at the various crossings.

Such protection would have involved considerable initial and annual expenditures of public funds if approved by the City Commission. The school crossing survey revealed that the reported hazard at most of these crossings was greatly exaggerated and that the recommended installations could not be justified. On the other hand, five of the crossings were found to have the "unsafe" classification and funds were approved by the City Commission for the employment of crossing guards on the basis of the findings of the school crossing survey.

The safety of school children at pedestrian crossings should be of sufficient concern to public officials and school authorities to encourage the initiation of periodic surveys of hazard conditions at all school crossings in an effort to keep pace with ever changing traffic conditions and provide protection for school children where facts reveal such a need. A method of survey for obtaining the facts and a method of evaluating these facts are offered in this study in the hope that it may be expanded into something of value towards solving the school crossing hazard problem.

Due to limited time, funds and personnel, extensive check-backs and further research were impossible. Possibly through the experiences of other cities, further insight may be obtained into the practicality of these theories and procedures with the result that sound warrants may be established for school crossing protection which will assist public officials in solving this important problem.

The Department Store and Parking

CHARLES O. PRATT

Mr. Pratt is employed as a Junior Traffic Engineer with the Division of Motor Vehicles, Department of Law and Public Safety of the State of New Jersey. Previously, he was engaged in research work in preparing a textbook on Traffic Control and Regulation, as a staff member of the Bureau of Highway Traffic, Yale University.

BUSINESS men and local government officials have gradually awakened to the fact that the life of the central business districts in their city is being slowly but surely snuffed out by the creeping paralysis that characterizes the parking problem. Much has been written about the many phases of the parking problem: it has been well defined and most of its intricate aspects have been set forth.

But on at least one phase of the overall parking problem, only limited information is available. This is the measure of parking demand and its correlation with land use. The best solution of the parking problem demands a considerable amount of factual information to achieve proper planning for the relief of the parking situation.

Many of our large cities have had the need for factual data brought home to them in seeking some solution to the parking problem. The usual result was a comprehensive parking survey of the entire downtown area or central business district. Such surveys do help to establish the overall demands on the area for parking facilities but do not, for the most part, pinpoint the demand to individual parking generators.

Most of the parking surveys have limited the determination of the demand to entire blocks or to block fronts on the four sides of the normal city block. Little has been done to go beyond that and indicate the attraction that individual business establishments have for automobile-driving customers.

In the last few years, however, there has been a growing interest in the parking demand generated by various types of land uses, both

as individual generators and as component parts in a group of generators. This interest directly results from an increasing appreciation of the parking problem and of efforts to solve it. The demand generated by individual types of land use has become important because of efforts to assign responsibility for the support of off-street parking developments and also because of efforts to write the provision of parking space into new zoning and planning ordinances. These tasks necessitate a factual knowledge of the parking demand and since very little had been done to determine the demand as specifically as this would require, surveys had to be made to arrive at proper parking demand figures.

Early Studies of Parking Generators

Many early parking surveys recognized the degree of accuracy that would be essential to the proper solution of the downtown parking situation but few of these made full use of the information. Among the most noteworthy studies of parking demand in recent years, aimed at the determination of the generating abilities of individual generators, was that conducted in Baltimore.[1]

The study made use of origin and destination survey data and the parking space requirements that resulted were based upon a sample of the total number of all types and purposes of trips into the central business district. It was found, for example, that what we call the "parking ratio"—the floor area of the generator which demands the provision of one parking space—ranged from 180 to 518 for three individual department stores in Baltimore. This means that, based upon the origin and destination data, there was a maximum demand for parking spaces by persons shopping in these stores of one space per 180 square feet of selling floor area in one, and one space per 518 square feet of selling floor area in the other.

Interesting recent studies of individual parking generators also have been made in Providence, R. I.[2] and Portland, Oregon.[3] It

[1] Thompson, J. T., and Stegemaier, J. T., "Effect of Building Space Usage on Traffic Generator and Parking Demand," *Highway Research Board Proceedings*, vol. 28, 1948, p. 320.

[2] "Report of Project Committee on Parking," *Highway Research Board Proceedings*, vol. 26, 1946, p. 44c.

[3] Portland Metropolitan Area Traffic Survey, *Portland Parking Survey*, 1946, p. 46.

has been found in Providence, for example, that the parking ratios in that city are considerably higher than those just cited for Baltimore. Table I shows the parking ratios obtained in downtown Providence as a result of a comprehensive parking survey.

TABLE I[4]

Parking Ratios of Various Land Uses in Downtown Providence

Land Use	*Parking Ratio*
Department Store	1350
Hotel	2000
City Hall & Offices	800
Offices and Bank	1150
Small Retail & Drug Stores	2600

The Portland study, also based upon the result of a full-scale parking survey, found for a downtown department store a parking ratio of 519 during the average hour of the average shopping day and a ratio of 423 for the peak hour of the average shopping day.

Another interesting study conducted in New Haven, Connecticut,[5] has produced parking ratios for a number of small downtown generators. Each of the studied generators was a type of small to medium retail store. Table II sets forth the parking ratios determined in this study as measured by the number of drivers in the parking generator through a 15-minute period.

TABLE II[6]

Parking Ratios of Selected Retail Stores in New Haven

Land Use	*Floor Area, Sq. feet*	*Parking Ratio**
Clothing store	23,250	1940
Men's clothing store	13,000	1680
Ladies shop	2800	930
Jewelry store	1870	625
Optical store	1870	375
Photo store	1050	350

* Based upon accumulation of drivers during three or more 5 minute periods.

[4] Source: "Report of Project Committee on Parking," *Highway Research Board Proceedings*, vol. 26, 1946, p. 440.

[5] Hutter, J. A., *The Retail Store as a Parking Generator*, Student Thesis, Bureau of Highway Traffic, Yale University, New Haven, Conn., 1948, p. 41.

[6] Source: Hutter, J. A., *The Retail Store as a Parking Generator*, Thesis, Bureau of Highway Traffic, Yale University, New Haven, Conn., 1948.

Each of these studies has presented interesting information regarding the demand for parking space generated by individual downtown establishments. However, a major factor in the determination of the extent of the parking problem in the downtown area is the effect which such extensively developed areas have on the demands of individual generators. None of the studies as set forth above has attempted to analyze the effects of this grouping of generators which results in what we shall call multiple destinations.

These are the practices of drivers or shoppers when visiting built-up areas to stop in a number of generators while in the area. The practice of visiting a number of generators on one trip makes difficult the task of accurately determining the parking demand of individual generators. However, this practice is followed in our downtown area by a high percentage of the shopping and parking public, with the result that it must be considered in the solution of the parking problem.

In an effort to determine certain characteristics of this problem of multiple destinations of downtown shoppers and also to add to the growing volume of data relative to parking ratios of traffic generators, a study was undertaken in March, 1950 in the city of Bridgeport, Connecticut.

A primary or major traffic generator was desired as a basic unit for which the parking demand could be measured. A department store was chosen as a typical primary traffic generator and arrangements were made with officials of the D. M. Read Company of Bridgeport so that the study might be based in that store.

Study Background

Bridgeport is a typical New England industrial community with a population of approximately 165,000. Its downtown area suffers from the usual old-city ills; narrow streets in an irregular pattern and inadequate parking facilities. This downtown area serves as the marketing center of a densely populated residential area that includes the towns of Stratford, Fairfield, Milford, Trumbull and Monroe.

The D. M. Read Company is one of three large department stores

in downtown Bridgeport. The store has been a major generator of parking demand since its opening in 1927. Its five-story building represents a gross selling floor area of 105,000 square feet. This total is the sum of four floors of 20,000 square feet and one floor and the basement with 12,500 square feet.

The D. M. Read store is situated on the northeast corner at the intersection of Broad and John Streets in Bridgeport. Entrances to the store are provided from Broad Street, John Street, and from the Post Office Arcade, a pedestrian walkway along the north side of the store.

From the officials of the D. M. Read Company, observations made previous to the survey field work and from earlier investigations into various aspects of the parking problem, considerable information was obtained which was important in establishing a study procedure.

The variation in dollar value of sales on a day-to-day basis throughout an average shopping week was sought in order that a working knowledge of the approximate variation of the parking problem would be available. Store officials provided the figures set forth in Table III.

TABLE III

Weekly Variation of Read's Sales

Day	*Per Cent of Weekly Sales*
Monday	0 (Store closed)
Tuesday	19
Wednesday	15
Thursday	30
Friday	16
Saturday	20
Total	100

These figures are believed rather clearly to reflect the habits of people shopping in the central business district of Bridgeport. The high percentage of the weekly sales as recorded for Thursdays reflects the 9:00 p.m. closing hour in effect on that day. The second high day for the average selling week is Saturday. This would be the peak day if the store hours on Thursday were the same as on the other days

of the week. Regardless of the effect such a change would have, Tuesday is considered the average shopping day. This of course is based upon the assumption that the volume of sales directly reflects parking demand. While we have no proof that this relationship is a true one, it is reasonable to believe it does exist.

Data were sought that would establish the comparative volume of shopping done during the twelve months of the year in the Read store. Since such information could not be obtained for this specific store, the results of previous research into characteristics of parking demand throughout the year as listed in Table IV were relied upon.

TABLE IV[7]

Seasonal Variation in Parking Activity

Month	*Per Cent of Yearly Total*	*Month*	*Per Cent of Yearly Total*
January	7.2	July	7.5
February	7.2	August	8.0
March	8.2	September	8.2
April	8.9	October	9.2
May	8.5	November	9.0
June	8.4	December	9.0

Monthly Average—8.25

These data are based upon the use of parking garages primarily by department store shoppers in central business districts, and indicates that the months of March and September are the average months. Since these data were obtained in a city comparable to Bridgeport in its annual shopping pattern, the data are felt to be applicable to Bridgeport's shopping pattern. On this basis, therefore, we may assume that the month of March represents the average shopping month of the year. Considering the information set forth above relative to the weekly variation in store sales, it appears that a Tuesday in March is a truly average shopping day. With this determined, the study was planned so that a measure of the parking demand on such an average day might be obtained.

[7] Source: Adapted from Lee, Edwin C. M., *Parking Characteristics of Department Store Garages*, Student Thesis, Bureau of Highway Traffic, Yale University, 1947.

Study Procedure

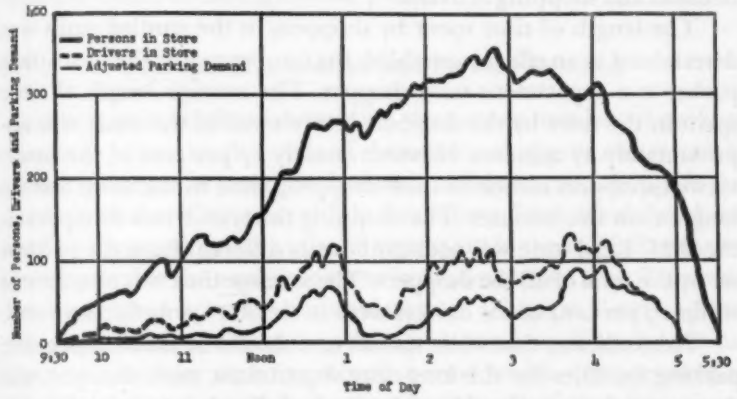
The nature of the information required for the successful conduct of the study limited the manner in which this information might be obtained. It was necessary to know the total shopping turnover in the store, the number or proportion of the shoppers who gained access to the store by means of the automobile, and some of the habits of these shoppers if the parking demand of shoppers visiting the store was to be measured.

An investigation of the established methods of conducting parking surveys and related studies failed to disclose any techniques that could be applied directly to this problem. It was obvious, however, that a store door count would be required. In addition to this, customer questionnaires as in a postcard survey, personal interviews with customers at the store doors, or customer interviews within the store by the sales personnel were determined to be necessary. The second of these alternatives in conjunction with the store door count was established as the proper procedure for gathering the required data.

Personnel requirements limited the field study to a pair of four-hour study periods. These periods, chosen on different days, were pooled so that the finished survey would present the total parking demand and parking characteristics of a representative Tuesday in March, the average shopping day. Analysis of the field data revealed that different shopping conditions prevailed during the two days on which field data were collected. For example, the turnover of patrons in the store was considerably lower during the day on which the second four-hour survey was conducted than it was on the day of the first study period. Proper adjustment of data placed the two counts on a comparable basis.

While the store door counts were being made, interviewers at each of the three exits from the D. M. Read store questioned persons leaving the store as to their time of arrival downtown, method of arrival downtown, number of shopping destinations prior to entering Read's, time spent in Read's, and their future shopping plans in the downtown area. Interviewing was conducted on a random basis with the interviewers approaching as many of the persons leaving the

store as possible. The interviewers were able to question about 5 per cent of the persons leaving the store. While this seems a low percentage of the total number of shoppers, it does not reflect the ratio of refused interviews. The percentage of refusals which made up the number of persons approached was approximately 38 per cent. This was due to a number of factors. The study was conducted with-



Accumulation of Persons and Drivers and the Average Day Adjusted Parking Demand
D. M. Read Department Store, Bridgeport, Connecticut

FIGURE 1

out the benefit of publicity usually so important to the success of parking surveys in other cities. Although the interviewers were identified by badges as to the purpose of the study and why shoppers were being queried, many persons professed to be in a rush and therefore not able to stop and answer questions. This was especially true through the noon hours. Many people also simply didn't want to be bothered.

Survey Results

Control of the results of this survey of parking demands of department store customers is based upon the accumulation of shoppers in the D. M. Read store, as measured by a day-long store count. This count, which establishes the number of shoppers in the store at any five-minute interval throughout the shopping day, is illustrated in

Figure 1. The period of greatest shopping activity will be noted to occur between the hours of 2:30 and 3:00 P.M. This accumulation curve checks rather well with accumulation curves showing the total of automobiles in the downtown areas of other cities, as determined by cordon counts in connection with comprehensive parking surveys, indicating a probable close coordination between parking demand and shopping activity.

The length of time spent by shoppers in the studied store was determined in an effort to establish the importance of the short-time parker as a department store shopper. The average length of time spent in the store by the shoppers interviewed in the study was approximately 27 minutes. However, nearly 17 per cent of the interviewed shoppers indicated their shopping time in the store was no longer than five minutes. The shopping times of driver-shoppers in the D.M. Read store was not significantly different from the pattern set by the total of all the shoppers. The average time was 28 minutes while 15 per cent of the drivers were in the store only five minutes.

This indicates that while special care should be taken to provide parking facilities for the long-time department store shopper, the short-time shopper should not be ignored. Further support for this argument is found in the fact that half of the drivers who spent five minutes in the store had made previous shopping stops in the downtown area and the average time spent in that area by these drivers was in excess of 45 minutes. This amounts to an average of 25 minutes spent at each of the previous stops for each driver. The half of the drivers who spent five minutes or less in Read's and had no previous destinations can be assumed to have arrived in the downtown area a short time before they were interviewed with the result that their shopping itinerary was just beginning.

The accumulation of automobile drivers in the D. M. Read store, a function of the accumulation of all shoppers and the proportion of interviewed shoppers found to be drivers, are shown with the accumulation of shoppers in Figure 1. The maximum number of drivers in the store during any five-minute period throughout the day is 133 drivers indicating a maximum demand of 133 parking spaces. Provision of this number of parking spaces, however, will mean that throughout all periods of the day, with the exception of the one five-minute period, such a parking facility will be operating

under capacity. Therefore, establishment of some lesser number of parking spaces as the practical space requirement should be made. The accumulation curve shows secondary peak at a total of 115 vehicles. To provide this number would result in an unsatisfied demand for 18 parking spaces during the peak demand period, but would provide adequate space throughout approximately seven and one-half hours of the eight-hour period.

Multiple Destinations and Parking Demand

Another approach for determining the proper number of parking spaces to meet the demands of downtown shoppers makes use of data relative to the multiple destination of downtown shoppers. An analysis of the effect of multiple downtown destinations has been made by determining the relative time spent in the D. M. Read store as compared to the total time spent in the downtown area. This ratio has been based upon the accumulation of drivers in Read's against the accumulation of drivers in the downtown area. Thus a ratio has been obtained for each five-minute period which, when applied to the total driver-shoppers in the store during each of these five-minute periods, results in the number of parking spaces that should be furnished to provide adequately for the Read's customer at any period throughout the day.

It may be noted from Figure 1 that a total of 96 parking spaces should be provided during the five-minute period of greatest demand for parking spaces. This demand occurs shortly after 4:00 P.M., in contrast to the period of greatest shopper-driver accumulation in the store, which occurs at 3:45 P.M. Difference in the time of occurrence of the peak accumulation of shoppers in the store, the peak accumulation of driver-shoppers in the store, and the period of maximum parking demand, is considered to be a function of the interview procedure followed in this survey. Since the only persons questioned were those leaving the store, the ratio of persons in the store to persons in the downtown area was bound to be higher during the late afternoon period when fewer persons were arriving downtown. This results in a disproportionately heavy percentage of driver-shoppers in the store after 3:30 P.M. as recorded in the survey data. As in the analysis of parking spaces required for the accumu-

lation of drivers in the store, a modified figure should be considered, in the neighborhood of 66 spaces as shown by the secondary peak accumulation occurring at that figure.

Analysis of Resultant Parking Ratios

With the number of shopper-drivers in the store at various periods through the average day determined, it is possible to determine parking ratios for the store based upon the two measures just set forth. Thus parking ratios, based upon the accumulated drivers in the store and the adjusted parking space requirements, may be established. In each case these ratios reflect only the average shopping day demands of the store customers. Peak shopping days such as Thursdays and Saturdays will not necessarily find these ratios applicable and the ratios do not make provision for store employees who, if properly provided with parking spaces, would lower the ratios substantially.

The gross selling floor area of this store is 105,000 square feet. The parking ratio, based upon the provision of a parking space for each driver-shopper visiting the store, is 790. This ratio reflects the peak accumulation of 133 driver-shoppers. The modified accumulation of 115 customers results in a ratio of 915.

Parking ratios based upon the multiple destination, adjusted parking demand peak of 96 spaces and the modified multiple destination adjusted parking demand of 66 spaces have been determined to be 1100 and 1590 respectively. In other words, if this store is to provide parking facilities for its customers, it would have to fill an existing average day demand of either one parking space for each 1100 square feet of selling floor area if it is to base the demand for parking space upon the proportion of total shopping time the driver-shopper spends in this store, or of one parking space for each 1590 square feet of selling floor area if the demand is modified by the limitations of the study technique.

It must be remembered that these figures make no attempt to measure the additional parking demand which will be generated by the provision of parking facility or the additional demand encountered on a peak shopping day. The additional drivers desiring

space as a result of these demand factors will considerably reduce the parking ratios advanced above.

While it is not possible to compare the parking ratio based on the multiple destination factor with any previously determined ratios, it is possible to compare the ratio based on driver-shopper turnover in the store with ratios established in other cities and for other types and sizes of generators. A number of parking ratios were reported earlier in this paper for department stores in various cities in this country. The range of this group of ratios, all for department stores, is from 180 to 1350. Included within these limits are ratios of 423 and 518 and 519.

Since no standard technique was applied in arriving at these ratios, no specific conclusion can be drawn as to the relative merits of the various ratios. However, it should be noted that included in the determination of the lower ratios were the demands of store employees as well as customers. Such immeasurable factors as the existing availability of parking spaces and the adequacy of urban transit facilities also enter these ratios and help to cause the wide variation in the results.

Summary

Based upon results of this study and experience gained in conducting it, a number of observations can be made relative to the application of data obtained. A study of this type carried on in conjunction with a full scale downtown parking survey can furnish valuable information to aid in the solution of a city's parking problem.

Accurate determination of parking demand generated by various downtown generators and the interrelation of this demand as caused by the multiple destination practices of persons shopping in the downtown area will be possible with results of this type of survey, conducted on a large scale. The two most important uses of information thus obtained are in establishing proper parking requirements in a zoning law, and in properly proportioning responsibility for parking facilities in a program such as an off-street parking plan. Fixing financial responsibility for the support of jointly sponsored parking lots is also possible with a knowledge of the generating powers of each of the sponsors, as provided by a study of this type.

Effect of Financial Responsibility Law on Accident Reporting

ALFRED M. KAHL AND A. R. LAUER

Mr. Kahl, graduate of the School of Law, State University of Iowa, practiced for several years before serving as a Judge Advocate in the Armed Services. In 1945, he was appointed Commissioner of Safety for Iowa and during this period inaugurated many changes in the department in the interests of safety. Besides strengthening the drivers' license laws he succeeded in getting the Financial Responsibility Law passed in Iowa. He also established the Iowa Safety Congress, a state-wide program of general safety.

Dr. Lauer is Professor of Psychology and Director of the Driving Laboratory at Iowa State College at Ames, Iowa. During the winter quarter of the academic year of 1936–37, he was associated with the Bureau of Public Roads in Washington, D. C., on leave from Iowa State College. He is the co-author of "The Motor Vehicle Driver" and author of several monographs and articles on highway signs and highway safety.

FOR several years the Driving Laboratory at Iowa State College has been attempting to validate driving performance against accident records. In a cooperative study with Harvard University in 1936–37 in Connecticut, it was suggested by Johnson (1946), and later shown, that the reliability of accident reports from groups of individuals over successive three-year periods was only about .20. This is extremely low.

Considering the imperfect reliability of most tests, it would be startling if validity coefficients of any magnitude could be obtained for any type of driving aptitude tests with accidents used as the criterion. By validity of a test is meant the degree to which it measures what it is supposed to measure. Reliability refers to the extent to which it measures consistently from one time to another. Criterion is simply an index or series of values against which a test is validated or its validity established.

EDITOR'S NOTE: This study was made possible through the Allstate Foundation for Driving Research.

Several reasons may be assigned for the low reliability of accident records. They may be summarized briefly as follows:

1. It is true that a relatively small proportion of the driving population are involved in violations or accidents for any one year. For Iowa this has been found to be approximately one fatality for every 2,300 drivers of the age group 20 and below; one fatality for every 1,650 drivers for the age group 20–24; one fatality for every 3,140 drivers for the age group 25–64 and one fatality for every 2,910 drivers 65 and over.

Unfortunately, state records do not break reporting down by years so that small age groups could be compared. Accidents not involving fatalities calculated from the usual constant of 1:35 would be 35 times this number in each group. assuming non-differential reporting on the basis of age. Violations run somewhat higher than accidents for men and somewhat lower than accidents for women. However, women have slightly better accident records than men. Thus only one out of 50–100 persons in Iowa have accidents each year. About the same proportion have violations reported on them each year. Relatively few persons run afoul of traffic laws and during a one-year period a certain element of chance is involved as to which ones are picked up by enforcement officers. A much higher percentage probably violate traffic laws and have accidents that are not recorded or fall below the legal amount of damage required for reporting.

2. The difference in rate of reporting in any one state has not been intensively studied, but it is reasonable to assume that as long as the state machinery has reached a certain point of development and conditions remain about the same, such variation would not be greatly different from year to year. Any change in conditions such as war, administrative policies, political upheavals, etc. might very well result in changes.

3. A third cause of law reliability of accident records might well be due to changes of address and the wide coverage of states by vacation and other driving, particularly when reporting is not reciprocal nor cooperation between the states fully practiced. A resident of New Jersey or Rhode Island may well drive ninety per cent or more of his mileage in other states. Unless accidents are

reported to the home state the results may be expected to fluctuate from year to year.

The Problem

Since uniform reporting is essential to sound accident statistics, a study was made to ascertain possible variations in this respect.

Two fundamental problems set up for solution were as follows:

1. How will a Financial Responsibility Law operate to improve accident reporting practices?
2. To what extent is reporting uniform over a state such as Iowa where a large part of the area is rural in nature?

On January 1, 1948, the Financial Responsibility Law went into effect throughout the state. In the winter of 1950, a cooperative research study was set up in which every 200th license was drawn from the State Drivers' License Files and all accidents and moving violations other than overloads were tabulated along with other data from the jacket of each license drawn. The primary purpose of the study was to evaluate the problem of age differences on accident involvement and the effect of training upon driving performance. The present study represents a by-product of this research which is quite relevant to the general findings and which may be of value to anyone having to do with accident prevention.

Method and Procedure

In order to be able to more adequately evaluate each driver's record, the date of each accident was copied on each individual data sheet. From these sheets the number of accidents and violations were tabulated by year since a system of accident recording was inaugurated by Iowa in 1933. Thus the year of reporting was tabulated without regard to the age of the driver.

This was likewise done separately for women. In reading the successive tables given in per cent, it is well to mention that there were three times as many men driving during this period as women and that the men were found to average almost three times as many

miles per licensee. Summarizing this point it may be stated that for accidents, the male drivers covered 90 per cent of the mileage and had 91 per cent of the accidents. The difference was not statistically significant and when tested by X^2 [1] showed only 1.816 which, to be significant at the 5 per cent level, would need to have been 3.841 or greater. The results of accidents reported from these tabulations are shown in Table I and Table II.

Table I

ACCIDENTS REPORTED IN THE STATE OF IOWA BY YEAR—MEN

(Tabulation of 1743 accidents from 5500 cases)

Year	*Per Cent*[2]	*Year*	*Per Cent*	*Year*	*Per Cent*
1933	—	1939	4.0161	1945	4.3029
1934	—	1940	5.3930	1946	.3442
1935	—	1941	5.9667	1947	8.6059
1936	.0574	1942	4.4177	1948	29.2025
1937	1.3196	1943	3.3276	1949	27.0797
1938	2.3523	1944	3.4998	1950	.1147[3]

Table II

ACCIDENTS REPORTED IN THE STATE OF IOWA BY YEAR—WOMEN

(Tabulation of 89 accidents from about 1900 cases)

Year	*Per Cent*	*Year*	*Per Cent*	*Year*	*Per Cent*
1933	—	1939	—	1945	3.3708
1934	—	1940	1.1236	1946	—
1935	—	1941	5.6180	1947	5.6180
1936	—	1942	—	1948	42.6966
1937	1.1236	1943	2.2472	1949	37.0787
1938	—	1944	—	1950	—

Thus it is shown that while the reporting of violations by state and local authorities remained fairly constant up to 1947 when there was an increase (See Tables III and IV), the reporting of accidents does not parallel this index. Over 56 per cent of men's accidents recorded in the Iowa Drivers' License Files occurred in 1948–49, or

[1] Chi square is obtained by determining the ratio of accidents which actually happened to those expected from the number of drivers in the groups compared.

[2] Per cent of all accidents in Iowa reported in the total period 1933–1950.

[3] To May 12, 1950 so far as records were complete.

the first two years of the Financial Responsibility Law. About 80 per cent of women's accidents were reported during the same period. Analysis of reported violations is given in Table III and Table IV.

Table III

VIOLATIONS REPORTED IN THE STATE OF IOWA—MEN

(Tabulation of 2514 violations from 5500 cases)

Year	*Per Cent*	*Year*	*Per Cent*	*Year*	*Per Cent*
1933	.0796	1939	3.3015	1945	6.7223
1934	.0398	1940	4.3754	1946	7.7565
1935	.5171	1941	4.0175	1947	13.0072
1936	.9944	1942	4.4948	1948	14.7176
1937	2.3468	1943	3.8186	1949	18.3373
1938	3.4606	1944	5.6085	1950	6.4041[4]

Table IV

VIOLATIONS REPORTED IN THE STATE OF IOWA—WOMEN

(Tabulation of 69 violations from about 1900 cases)

Year	*Per Cent*	*Year*	*Per Cent*	*Year*	*Per Cent*
1933	—	1939	1.4493	1945	7.2464
1934	—	1940	2.8986	1946	7.2464
1935	1.4493	1941	5.7971	1947	13.0435
1936	—	1942	8.6956	1948	17.3913
1937	1.4493	1943	—	1949	14.4928
1938	4.3478	1944	10.1449	1950	4.3478[5]

Here it will be observed that after the machinery got into action there was a fairly consistent number of violations reported annually, even through the war years for both men and women. In 1946, however, there was a low point in reporting, probably due to a change in administration and a tendency to overlook the errors in driving of the returned veteran and thus "give him a break."

About the same results were noted for women. Then something drastic occurred in 1948. The reporting of accidents increased beyond all reasonable expectations and of course there seems but one answer: the Financial Responsibility Law which went into effect

[4] To May 12, 1950 so far as records were complete.
[5] To May 12, 1950 so far as records were complete.

January 1 of that year. It made mandatory that all accidents over $50 be reported.

In the process of analyzing the complete research study, it was found necessary to compare accident rates in rural areas with those of urban areas. Some startling results again are to be noted as shown in Table V. Groups shown at the left of the table represent counties grouped in such a way as to approximate similar proportions of the state population. Group I contains but one county, while the number of counties increases in number as the group designations increase. Thus they vary from one up to fifteen depending on the density or sparsity of population. At first the differences appeared real and by statistical analysis they were mostly significant to a high level of confidence.

As a check on the validity of accidents reported as being a true measure of traffic difficulties, it was thought advisable to compare fatalities with accidents reported in the same groups of counties. The annual number of deaths per county for the years 1946, 1947, 1948, and 1949 were added to get a mean standard of comparison. The results are shown by population groups in Table V.

Since the extremely high values of X^2 is of the order of 677.8715 it is almost certain that the two arrays do not represent a common distribution since any value of this index over 3.841 is considered significant. Therefore the reporting of accidents is not uniform through the range of counties as grouped according to density and sparsity of population per county. Also the ratio of accidents reported to deaths from motor vehicles varies greatly from one population group to another.

Summary and Conclusions

Data are presented on the accident and violation reporting index for the State of Iowa during the years 1933–1949 inclusive. Only the first part of 1950 was included. Also the relationships between accidents reported and fatalities over a period of years are evaluated by standard statistical techniques to determine whether a constant ratio of deaths to accidents exists between all groups of counties ranging in population from 193,000 to 268,000. For the most part,

Table V

Comparison of All Accident Cases Reported for 1948 and 1949 with Fatalities for 1946–1947 and 1948–1949 Occurring in 12 Groups of Counties Listed in Descending Order of Traffic Density

(Fatalities used as a base for calculating the theoretical or expected frequencies.)

Group	Accidents 1948–1949	Fatalities 1948–1949	Probability of Fatality[6]	Products	Group	Accidents 1948–1949	Fatalities 1946–1947	Probability of Fatality	Products	Ratio of Fatalities to Reported Accidents 1946–47–48–49 Combined
I	222	87	0.3919	34.0953	I	222	63	0.2838	17.8794	1:296
II	131	58	0.4427	25.6766	II	131	80	0.6107	48.8560	1:190
III	150	105	0.7000	73.5000	III	150	112	0.7467	83.6304	1:138
IV	131	103	0.7862	80.9786	IV	131	91	0.6949	63.2086	1:135
V	103	61	0.5922	36.1242	V	103	76	0.7379	56.0804	1:149
VI	88	103	1.1704	120.5512	VI	88	79	0.8977	70.9183	1:97
VII	99	110	1.1111	122.2210	VII	99	111	1.1121	123.4431	1:92
VIII	100	103	1.0300	106.0900	VIII	100	101	1.0100	102.0100	1:133
IX	116	99	0.8534	84.4866	IX	116	77	0.6638	51.1126	1:133
X	82	104	1.2683	131.9032	X	82	102	1.2439	126.8778	1:80
XI	98	99	1.0102	100.0098	XI	98	102	1.0408	106.1616	1:97
XII	87	84	0.9655	81.1020	XII	87	76	1.1447	86.9972	1:109
Total	1407	1116		996.7385	Total	1407	1070		937.1754	

divided on the basis of density of population, there is a marked and significant excess of reporting in the densely populated counties and a deficiency of reporting in the sparsely populated counties.

Considering the scope of the study and the data available, the following conclusions may be considered:

1. The number of violations reported is not a reliable measure of accidents reported within a given area and during a specified time.

2. The enactment of a State Financial Responsibility Law requiring a report of all accidents beyond certain limits of property damage increased the number of accidents reported in Iowa.

3. The reporting of accidents is not proportional to the number of fatalities occurring within a given geographical area and period of time under comparable state regulations.

4. There is fairly high consistency of measurement between the

[6] See Snedecor (1946).

number of accidents occurring in specified areas during successive two-year periods when population groups of around 200,000 population are considered, yet individual groups vary greatly in their reporting index with the density of population.

5. Various hypotheses may be advanced to explain the reason for the discrepancies noted which is beyond the scope of this study.

The conclusions drawn are not considered by the authors to hold outside the State of Iowa until such studies are made or results confirmed. Adequate data and a satisfactory sampling technique, however, were used to establish a reasonable degree of confidence in the conclusions as they apply to the population studied.

References

Johnson, H. M., The detection and treatment of accident prone drivers. Psychol. Bull., 1946, *43*, #6, pp. 488–532.

Lauer, A. R., Concerning the establishment of a criterion and certain incidental points relating to validity coefficients. Proc. Iowa Acad. of Science, *45*, 1938, pp. 259–262.

Lauer, A. R., Improvement of test criteria. Proc. Iowa Acad. of Science, *54*, 1947, pp. 239–241.

Snedecor, G. W., Statistical Methods, Iowa State College Press, 1946, p. 206.

THE ENO FOUNDATION FOR HIGHWAY TRAFFIC CONTROL

THE BOARD OF DIRECTORS

COLONEL ROBERT C. F. GOETZ, U. S. A. Retired, *Chairman and President*

COURTLAND KELSEY, Attorney, New York, N. Y., *Vice President*

CHARLES M. UPHAM, Consulting Engineer, Washington, D. C., *Vice President*

GEORGE PARMLY DAY, *Yale University*

ALBERTA A. ENO

PHILIP K. SMITH, New York, N. Y., *Treasurer and Assistant Secretary*

MARY S. BRIODY, *Secretary and Assistant Treasurer*

ROSCOE ELLARD, In Charge of Instruction, Graduate Journalism Faculty, Columbia University, New York, N.Y., *Editorial Consultant*

WILBUR S. SMITH, Associate Director, Bureau of Highway Traffic, Yale University, New Haven, Conn., *Technical Advisor*

EDWARD G. MOGREN, *Resident Traffic Engineer*

THE BOARD OF CONSULTANTS

Terms Expire February 1952

RANDOLPH COLLIER, California State Senator, Sacramento, Cal.
WILLIAM ENO DEBUYS, Baltimore, Maryland
W. L. GROTH, Department of State Police, Virginia
A. S. KEELER, Rye, New York
R. L. MORRISON, Professor of Engineering, University of Michigan
CHARLES SEYMOUR, President Emeritus, Yale University
T. E. TRANSEAU, Bureau of Highway Safety, Pennsylvania

Terms Expire February 1953

NATHAN CHERNIACK, Economist, The Port of New York Authority, N.Y.
THOMAS DESMOND, New York State Senator, Newburgh, N.Y.
D. C. GREER, State Highway Engineer, Texas Highway Department
BURTON W. MARSH, A. A. A. Washington, D. C.
ARTHUR MILLER, former Inspector, Metropolitan Police Department, Washington, D. C.
H. G. SOURS, Columbus, Ohio

Terms Expire February 1954

J. A. ANDERSON, Commissioner, Dept. of Highways, Commonwealth of Virginia
EDGAR F. COPELL, Traffic Engineer, Dept. of Public Works, Mass.
MAJOR GENERAL PHILIP B. FLEMING, Ambassador-designate to Costa Rica; Chairman, The President's Highway Conference, Washington, D. C.
MAXWELL HALSEY, Executive Secretary, Michigan State Safety Commission
PAUL HOFFMAN, President, Ford Foundation, Detroit, Michigan
THEODORE M. MATSON, Director, Bureau of Highway Traffic, Yale University
CHARLES M. NOBLE, Chief Engineer, New Jersey Turnpike Authority